

S Hazard tree
634.96 management plan
U9htmp Glacier National
1994 Park

HAZARD TREE MANAGEMENT PLAN

Glacier National Park
West Glacier
Montana, 59936

March 1994

STATE DOCUMENTS COLLECTION

1006

MONTANA STATE LIBRARY
1515 E. 6TH AVE.
HELENA, MONTANA 59620



MONTANA STATE LIBRARY



3 0864 0010 0440 0

HAZARD TREE MANAGEMENT PLAN

Glacier National Park
West Glacier
Montana
59936

March 1994

Prepared and Reviewed by the Resources Management Division

Prepared by:

David E Lange 4/11/94
Natural Resource Spec., Glacier Natl. Park

Laurie G Herth 4/11/94
Plant Ecologist, Glacier National Park

Recommended by:

Stephen Long 4/18/94
Chief Ranger, Glacier National Park

Approved by:

Jim R. [Signature] 4/29/94
Superintendent, Glacier National Park

TABLE OF CONTENTS

I.	INTRODUCTION	2
II.	AUTHORIZATION	2
III.	COMPLIANCE	3
IV.	PROCEDURES FOR OPERATIONS.....	3
	A. Annual Work Plan.....	4
	B. Survey to Identify Hazard Trees.....	5
	C. Select Mitigation Action.....	9
	D. Implement Mitigation Action.....	11
	E. Document Work.....	11
V.	SITE REHABILITATION AND/OR MONITORING.....	12
VI.	PUBLIC INFORMATION	13
VII.	ROLES AND RESPONSIBILITIES	13
	A. Resources Management Division.....	13
	B. Maintenance Division.....	14
	C. Interpretation Division.....	14
	D. Lands, Safety, Concessions Division.....	14
	E. Training.....	14
APPENDICES		
	A. DEFINITIONS	
	B. HAZARD TREE MANAGEMENT DECISION TREE	
	C. TREE RATING CRITERIA AND EXAMINATION PROCESS	
	D. PROBABILITY THAT A TREE WILL HIT A TARGET	
	E. HAZARD TREE SURVEY FIELD RECORD FORM	
	F. COMMON HAZARDS OF PARK TREE SPECIES	
	G. LITERATURE CITED	



I. INTRODUCTION

Glacier National Park consists of just over 1 million acres of which approximately 564,000 acres, or 57%, are forested. Numerous public facilities and roads as well as private homes are situated within these forests. Visitation continues to increase with more than 2,000,000 visitors using the park's roads and facilities. The potential exists for weakened trees or portions of trees to fall and cause injury to people and/or damage to property. Park management has a responsibility to reasonably protect visitors from unnecessary risks resulting from hazardous trees.

The purpose of Glacier National Park's Hazard Tree Management Program (HTMP) is to provide for the safety of people and property while protecting natural values. The Hazard Tree Plan (HTP) provides the guideline for assessing what trees represent a hazard; determining which facilities should be closed or relocated and which hazard trees should be removed; and assigning responsibilities for carrying out the program.

The objectives of the hazard tree program are:

1. Implementation of an aggressive, yet ecologically sound program that provides for regular prioritized surveys, evaluation of potentially hazardous trees and the removal or mitigation of tree hazards.
2. Preservation of ecosystem dynamics and structure, particularly the age classes and species diversity, while eliminating or mitigating hazards.
3. Consistency and continuity in tree hazard surveys, ratings, documentation, and evaluations of management alternatives.

II. AUTHORIZATION

The enabling legislation for the park as well as the Organic Act of the National Park Service mandates the preservation of the biological and historical diversity while providing for enjoyment by the people. It is the policy of Glacier National Park to manage the park as a pristine natural area while providing reasonably safe recreational opportunities to the public.

Impetus for the hazard tree program derives from aspects of liability. The Federal Tort Claims Act-1 46 (28 USC 2671-80 and 1346 [b]) provides the basis for the National Park Service to be held liable for failure or negligence with respect to visitor protection. Most interpretations of tort law make the landowner responsible for taking reasonable care to avert harm to visitors. Reasonable care may take the form of actions (closing the site,

moving a structure, removing the tree or parts of the tree) or warnings (public information and interpretive programs, handouts, postings, emergency procedures). Assumed risk by the visitor and leaving wild areas unaltered are not acceptable reasons for retreating from agency responsibility.

III. COMPLIANCE

The Hazard Tree Management Plan and subsequent program supplements the Resource Management Plan. Individual Environmental Assessments may need to be prepared for specific projects if they involve large scale or controversial activities. Special concerns may include rare and endangered species or their critical habitat, impacts to visual resources or cultural landscape values, impacts to soils and hydrology, significant alteration of local natural forest structure and composition, wildlife nesting or breeding periods, surface disturbance of archaeological sites, and/or cumulative effects of ongoing programs or extended projects.

IV. PROCEDURES FOR OPERATIONS

Although it is impossible to predict when sound trees will fall, it is possible to determine when trees have sufficient disease or other defects that make tree failure likely. A hazard tree exists when a tree or portion of a tree is in imminent danger of falling, due to disease or structural failure, and striking a person object, structure, or vehicle. Not all trees with diseases or structural defects are hazardous, only those that are significantly weakened. Trees out of falling distance to human-use areas, regardless of their condition, are not hazards because there is no target.

Trees with no detectable defects may fall during extreme wind events or due to unknown causes. The only way to eliminate all probability of damage by trees would be to remove all trees within human-use areas. This clearly counters the mandates and would decrease the quality of visitors' experiences.

This Hazard Tree Plan provides a procedure to identify hazard trees, select management actions, reduce the hazard and incorporate ecological concerns. Since there are some program revisions identified in this plan, it is necessary for employees to work closely with the staff Ecologist and Natural Resource Specialist (Field Resources) to ensure strategies are implemented as intended. The plan includes five actions (see Decision Tree, Appendix B):

- Write an Annual Work Plan.
- Survey to identify hazard trees.
- Select a mitigation action.
- Implement the mitigation action.
- Document Work

The first year of implementation of this program will be critical to determine its effectiveness and practicality. During the first year, the Natural Resource Specialist (Field Resources) and the Ecologist will work closely on surveys and selection of mitigation actions. This will enable evaluation of the rating criteria and the feasibility and interpretation of the rating system. Additionally, it can be determined if the mitigation actions as outlined effectively meet the visitor safety and ecological objectives. The program will be modified as necessary prior to development of the following year's annual work plan.

A. Annual Work Plan

The Natural Resource Specialist (Field Resources) coordinates the program as the Hazard Tree Team Leader. He/she organizes a Hazard Tree Work Team of employees from the Resources Management and Maintenance Divisions, and writes an Annual Work Plan. The goals, objectives and activities for each year are prioritized by the team based on funding, priorities, capabilities, and the previous years ecological evaluation. Following review and comment by the Park staff, the Annual Work Plan will be signed by the Superintendent.

The Natural Resources Specialist (IPM and Forestry) leads implementation of The Annual Work Plan, which includes:

1. Pending mitigation actions from previous surveys.
2. Trees that need to be reexamined.
3. Identification of areas for spring surveys.
4. Approved mitigation actions from spring surveys.
5. Vegetation rehabilitation actions that are pending.
6. Assignment of responsibilities and schedules for work accomplishment.
7. Identification of informational needs.
8. Monitoring needs.

Considerations to use in setting priorities are based on management zone designations. For the purpose of this plan, the park is divided into four different management zones based primarily on the amount and type of human use and development in each area. Within each zone are sub-areas, e.g. Apgar Campground, that have specific targets, including people, property and facilities that are referred to in the Annual Work Plan.

Developed Zone. Priority 1: Surveys are conducted annually in the spring, before facilities open. Areas within this zone are frequently used by visitors and employees with the highest probability of injury or property damage. The Park has encouraged visitors and employees to use and remain in these areas for travel, services, lodging, and recreation with a reasonable expectation of safety. Most visitor facilities are

campgrounds, visitor centers, lodging facilities, roads, housing areas.

Historic Zone. Priority 2: Surveys are conducted biennially in the fall. Areas are of cultural significance with limited to moderate human use with some potential for injury or property damage. Some of the historic buildings in this zone may be irreplaceable structures. Examples include backcountry cabins and old homesteads.

Special Use Zone. Priority 3: Surveys are conducted biennially in the fall. Areas are used by other agencies or companies (power and phone lines) which have some potential for injury or property damage. This Zone contains other types of land ownership and leases identified in the Land Protection Plan. The Park will usually not conduct surveys or take mitigation action on these lands unless requested to assist as a consultant. The land owner has responsibility for the mitigation of hazard. Use of the area is based on carrying out the special use permit. Private land owners control access to their property. Examples include railroad, powerline, phone lines, private lands.

Natural Zone. Priority 4: Surveys are conducted annually in the summer in areas of sporadic visitor use on a limited basis with low potential for injury or property damage. Inspections will be confined to areas with developed facilities such as backcountry campgrounds. Due to the number of miles of trails (730) in the Park and the very low residence time of humans in one spot on a trail, hazard tree surveys will not be conducted for trails. However, normal trail-clearing operations will remove trees hung up or leaning over trail corridors.

B. Surveys to Identify Hazard Trees

Yearly survey objectives are included in the Annual Work Plan formulated by the Hazard Tree Work Team. These note the type, time and staff responsibilities for the surveys. These objectives take into consideration frequency goals, recent notable weather events, past surveillance history and available funding for survey personnel and mitigation. It also includes a list of qualified personnel for the types of surveys prescribed (surveillance or examination). Even though certain qualifications are required for surveys, all park employees are encouraged to report potential hazard trees to the Natural Resource Specialist (Field Resources) for investigation.

There are two types of forest surveys used to identify hazard trees.

1. Surveillance surveys provide general oversight by walking or driving through an area and visually scanning the forest to detect potentially hazardous trees. Reports of potentially hazardous trees are reported to the Hazard Tree Team Leader by any park employees, concession employees or visitors (refer to Section IV.E, Document Work, and Appendix E). Surveillance may be part of a regular yearly work program, a normal part of spring opening, or occur after some wind events or snowstorms during the season. They may be conducted by trained members of the Hazard Tree Work Team.

During the survey, all trees that have recently failed (in the last storm or during winter) are noted. Species, size and suspected cause of failure are noted. When the number of fallen trees exceeds the time capabilities of the general surveyor, the trees are documented during the detailed examination. With this information we can determine the following: specific sites with tree failure problems, probability of tree failure by species, common cause of tree failure by species, and seasonality of tree failure. This data will be used for risk assessments, tailoring the Annual Work Plan towards problem areas, and long-term analysis of forest dynamics and human impacts.

Some forest habitat types have persistent problems with tree failures that require close monitoring. For example, cedar/hemlock forests with older age class trees are known to have extensive heart rot, especially in hemlock. Old-growth Douglas fir forests are known to have heart rot and root rot problems. Some uniform age stands of medium to older age lodgepole have mortality due to mountain pine beetle and windthrow. Therefore priority should be given to developments in and around these forest types.

2. Examination surveys are conducted by a trained hazard tree team member under the direction of the Natural Resource Specialist (IPM/Forestry). They are done concurrently or as soon after a surveillance inspection as is possible. Examinations are systematic, specimen by specimen evaluations of all potentially hazardous trees identified in the Surveillance Reports. The purpose of examination surveys is to make a risk assessment of detectable hazard trees to people and property. The examination and rating include species identification, description, measurement, defect assessment, wildlife use, hazard rating, mapping, tagging and documentation of location. The examiner may choose to rate the hazardous portion of the tree, rather than the whole tree, i.e. dead top or branches.

The hazard rating system is used to evaluate potentially hazardous tree conditions, and provide a guide for making decisions on mitigation methods. It is an assessment of risk that considers the probability of damage to a target. It also takes into account the target value. The hazard rating system is comprised of analysis of these factors, which are added as points in a two-part assessment. The results of all examinations are recorded on the Hazard Tree Examination Form (Appendix E), and kept on file in the Natural Resource Specialist (Field Resources) office at headquarters. All trees that have a hazard rating of 5-7 will be marked with a metal tag that is nailed to the base of the tree. Trees with a lower rating may be marked for future inspections. This tag has a unique identifying number that corresponds to the tree description on the record form. Based on the examination survey, interim warnings or closures may be put into effect.

Each tree will be carefully surveyed for presence of defects. Trees with defects will be rated low, medium, or high (1-3), as to their likeliness of failure during the current season (USDI, 1991). An extra point may be added if a tree exhibits other defects in addition to structural problems (i.e. lean). Trees with no defects will automatically fall into the no hazard category. If a tree has fallen, the suspected cause of the fall as well as any defects will be noted. Documentation on species, size, any defects present and cause of failure or date of removal will be maintained on each tree. The potential target will also be rated low, medium, or high (1-3) according to the value of the structure and/or human-use levels. Defects and guidelines for rating are below (modified from Wallis, Morrison and Ross, 1980).

Tree Failure Potential

A tree will be rated as to its potential for failure as follows:

- 0 - minimal potential for failure, no defects present
- 1 - low potential for failure, some minor defects present
- 2 - medium potential for failure, moderate defects present
- 3 - high potential for failure; dead trees, trees with serious defects, and those with multiple defects
- 4 - very high potential for failure, a tree with several serious defects and a lean resulting from causes other than natural growth

Appendix C provides guidance for determining tree failure potential.

Impact to Target

This rating considers the potential impact to a target if a tree were to fall on it. Included in this rating is the size of the tree or parts thereof, the probability of it hitting a target (appendix D), and the value of the target.

1 - minimal damage potential; probability of hitting target low, tree or parts thereof that could fail are small, target of low value, infrequent human use.

2 - moderate damage potential; medium probability of hitting target, tree or parts that could fail are of sufficient size to cause moderate damage, target could sustain some damage or is of moderate value, moderate human use.

3 - extensive damage potential; probability of hitting target high, tree or parts that could fail are of sufficient size to injure, kill or cause extensive property damage; targets include people and/or their property or high value public facilities, high human use.

In some instances, there will be conflicts in the potential rating. For example, a tree has a high probability of hitting the target, but the target is of low value and infrequently used and the parts of the tree that could strike the target are of moderate size. The examiner must balance the various issues to determine a rating. In the above case, the rating would be a 1 or 2 depending on the actual value and purpose of the target.

Hazard Tree Rating

The two ratings are added together to obtain an overall rating to determine hazard level and management action according to the following chart. Hazard determination and recommended action (modified from NPS-77, 1991).

Rating	Hazardous Condition	Recommended Action
0	No discernible flaw and no construed risk - not a hazard	No immediate action needed
1-2	Low - not a hazard	No immediate action needed.
3-4	Medium - not a hazard	Monitor annually or as recommended, but do not remove, or mitigate.
5-7	High - hazard	Top or remove the tree or defective limb(s) or move the target, or close the site.

Mitigation actions will be prioritized based on hazard rating. For example, actions will be implemented on trees with 7 rating before trees with 5 rating. Trees that are not hazards (i.e. those with no defects or with defects but not likely to fall) should be monitored annually in high use areas and less frequently in lower use areas to detect any changes in their condition that may change their status to a hazard.

C. Select Mitigation Action

The Natural Resources Specialist (Field Resources) coordinates the use of the Hazard Tree Management Plan Decision Tree to select alternatives for reducing risk from trees judged hazardous during the examinations. He/she is ultimately responsible for selection of a preferred alternative or obtaining a staff decision when necessary (see below). Selection of a mitigation action considers the prescribed criteria and coordination with Team Members.

Trees that are not hazards (i.e. trees with defects but not in imminent danger of falling and striking a target) are monitored to detect changes in their condition. Trees that are judged hazard trees require mitigation measures as soon as possible following the examination. Areas within striking distance of a hazard tree will be signed and closed to the public until full consideration of possible actions and removal of the hazardous conditions is completed.

There are three management actions to eliminate the hazard from trees:

- 1) the tree may be removed
- 2) the target may be moved, or the area closed to human use
- 3) the hazard portion of the tree may be removed

Mitigation alternatives must consider:

1. Aesthetic and historic values of the tree.
2. Ecologic value of the tree including wildlife forage and nesting, vegetation community dynamics (shading, seed source, etc.) and potential for windthrow following removal.
3. Number of trees recommended for removal and number of trees removed in previous years within the area.
4. Forest community, site conditions, susceptibility of site to having hazard trees, and species of trees.
5. Historic, social, and monetary value of the target.
6. Feasibility of closing the area or moving the target.
7. Management zone and the type and amount of visitor use in the area.

All reasoning for the final management decision must be well documented on a tree rating form. Staff review is mandatory for certain mitigation decisions and is handled through the Park Planning Process, Management Directive 15.1. At this point a specific time period for review is set. The mitigation decision will then be made by the Park Management Team.

Mandatory review decisions include:

1. Closure of facilities permanently or for an extended period of time. This may result from inability to remove the hazard or move the facility or temporary wildlife activity such as nesting birds.
2. Relocation of a target requiring extensive cost and/or planning (e.g. parking lot, campground, etc.).
3. Removal of trees when such removal results in a 10% or more loss of standing trees within the immediate environment.
4. Removal of known endangered species perch or nesting trees.

Absent these conditions (1-4) mitigation action may proceed with the approval of the Natural Resource Specialist (Field Resources).

D. Implement Mitigation Action

If a decision is made to remove hazard tree(s), all provisions for public safety, crew safety, sawyer skill level, and the removal of debris must be met. Cutting, removal of the tree and cleanup is coordinated by the Hazard Tree Work Team, as agreed upon in the Annual Work Plan. The Natural Resource Specialist (IPM & Forestry) is responsible for timely implementation of the selected action, and coordination with other activities such as campground opening and facility maintenance.

The number of trees removed each year may vary dependent on budgetary and personnel constraints. Contract and cyclic maintenance funds may be requested for the removal of trees. A list of qualified sawyers from the Maintenance and Resources Management Divisions is maintained by the Hazard Tree Work Team to utilize for tree removal throughout the park.

When high winds or other conditions threaten visitor safety due to hazards posed by falling trees or limbs, protection actions such as road, site or campground closures and the evacuation of visitors to safety areas may need to be taken. Closures and evacuation are addressed in the Emergency Evacuation Plan and are the responsibility of the District Rangers. Developed sites may be closed temporarily following severe wind storms until adequate surveys can be completed and mitigation carried out if necessary.

Temporary site closures are coordinated by the District Ranger. Seasonal or permanent site closures and/or moving of facilities are reviewed and approved by the management staff.

E. Document Work

Documentation is essential for any resource decision or manipulation that may lead to tort claims or scrutiny by interest groups or the general public. Additionally, detailed documentation assists in analyzing and improving the program. Computer software is developed to track potential hazard trees and initiate a database for program improvement.

The following documentation is maintained for the hazard tree management program. Please refer to Appendix E.

1. Trees identified during surveys are recorded on the "Hazard Tree Surveillance Record" form. Information in reports includes tree location, description of defect, species, estimated height and width, description of target and action recommended. These reports are submitted to the Natural Resource Specialist (Field Resources) in headquarters for evaluation. Surveillance reports are compiled and summarized on Case Incident Reports 10-343 by the Natural Resource Specialist. Potential hazard trees may also be recorded on maps of the developed area, with supporting

information.

2. Examination Surveys are recorded on the "Hazard Tree Examination Record" form. The form includes documentation of detailed inspections, results of criteria rating, decision on mitigation and date of implemented mitigation. Mitigation action is not implemented until information from the inspection is completed. Examination reports and resulting actions are summarized on Supplemental Case Incident Record 10-344 by the specialist.

3. Training courses and seminars attended by Hazard Tree Work Team members are documented in memorandum by the Hazard Tree Team Leader, and also recorded on a training form for the employees personnel file.

4. Tree failures that are not identified on Surveillance or Examination forms are recorded in the Report of Tree Failure.

5. All tree records will be maintained in a computer data base, updated each fall. The data base will be used to track trees and make ecological evaluations of the program. The Ecologist, working with the Natural Resource Specialist (Field Resources) and the Computer Specialist, will design and manage the data base.

V. SITE REHABILITATION AND / OR MONITORING

One of the ecological concerns with any tree removal program is the disruption of the natural community structure. In many cases, tree hazards occur in a well-developed forest with canopy and understory vegetation. Removal of a few hazard trees is not a significant disruption to the natural community. However, some sites suffer from heavy use which precludes development of understory vegetation (e.g. Lake McDonald lodge and complex). As trees die and/or are removed, there are no young trees to replace them. Eventually, the area does not have any overstory and is converted from a forest to a open grassland, shrub, or barren area. In areas where there is no understory, a rehabilitation plan should be developed which compensates for the long-term impacts of hazard tree removal. Canopy management strategies are to be included in the Vegetation Management Plan, currently under formulation.

The overall number of hazard trees previously removed is evaluated annually to detect and prevent undesired cumulative effects. Additionally, an assessment of the accuracy and reliability of the tree rating and rating criteria is conducted as funding becomes available. Reviews are conducted by the Natural Resource Specialist (field resources) and the Ecologist in the Resources Management Division.

VI. PUBLIC INFORMATION

It is important to communicate the goals and provisions of this plan to the staff through training programs, notices and individual contacts. This is especially important when removal projects are imminent or underway. It is critical to inform the interpretive staff, the Public Information Officer and other ranger and maintenance personnel who are working in or near the affected area.

The public should be informed where mitigation actions are occurring that may affect their activity planning. If tree removal is planned within facilities that are open, adequate signing and information is posted before actions are implemented.

VII. ROLES AND RESPONSIBILITIES

A. Resources Management Division

1. The Natural Resource Specialist (field resources) is the Hazard Tree Team Leader. He/she organizes a Hazard Tree Work Team composed of the District Rangers and the Facility Managers. The Work Team reaches consensus in planning the goals, objectives and activities for the year in an Annual Work Plan. He assists with public information and provides assistance in modification of the hazard tree management plan.

2. The Natural Resource Specialist (Forestry & IPM) coordinates supervision of surveillance and examination surveys, selection of mitigation actions, staff review when required, removal of hazard trees and cleanup. He/she assesses personnel qualification levels for surveys and tree removal, and coordinates training. A seasonal supervisory park ranger will lead field crews to implement the work, likely composed of employees from several divisions.

3. District Rangers participate as partners on the Work Team, and recommend priorities for surveys and mitigation. Subdistrict personnel assist with implementation of the Annual Work plan, as assigned by the District Ranger. Seasonal personnel may include fire crews and hazard fuel crews. Duties may include surveillance, felling trees or cleanup. They are responsible for informing visitors of significant weather events that could increase the hazard from trees and posting notices or signs and implementing the Emergency Evacuation Plan when needed.

4. Wilderness Manager and backcountry staff conduct surveys and mitigation at designated campsites and developed facilities within the backcountry and proposed wilderness.

5. Trails Foremen and crews may assist with surveys and mitigation within the backcountry and proposed wilderness. They

may be requested to fell hazard trees within developed areas.

6. Ecologist is primarily responsible for evaluation and modification of the hazard tree management plan. This includes ecological evaluation of work completed to determine long-term impacts, development and evaluation of rating criteria, modification of mitigation selection factors, and development of computer software. The ecologist develops and conducts research to improve the program. He/she reviews the annual work plan and provides technical assistance. In fall, the Ecologist prepares an annual ecological evaluation of the program and makes recommendations for modifications or management actions.

B. Maintenance Division

1. Facility managers participate as partners on the Hazard Tree Work Team to suggest priorities, plan work for the coming season and determine the level of assistance that can be provided. Maintenance crews participate in a support role with rangers in cutting of hazard trees or removal of debris from developed areas. The amount of time spent on hazard trees is dependent on funding, weather, scheduling and location.

2. The Landscape Architect reviews the annual work plan.

D. Interpretation Division

1. Interpreters may submit informal reports of potentially hazardous trees to the Hazard Tree Team Leader whenever they observed a tree that may be a hazard. They provide interpretation of hazard tree removal as necessary within campgrounds and developed areas.

E. Lands, Safety, Concessions

1. Hazard trees may be reported to the Safety Officer or District Safety Committees by any employees in a given area using the Hazard Condition Report. This record is maintained by the Safety Officer in computer files. The Safety Officer is a technical consultant regarding compliance of the program, and safety issues involved in mitigation methods.

2. The concessions specialist provides assistance in implementing this plan with the variety of concession operations in the Park.

F. Training

It is critical for employees involved in the hazard tree management program to have training in particular skill areas related to specific tasks.

For surveillance but particularly examination surveys the following skill areas and types of training are important:

a. Basic silvicultural and vegetation management principles; ecological relationships linking vegetation, insects and disease; arboricultural techniques and equipment; basic training in botany, dendrology, and/or plant pathology; Glacier National Park forest ecology and habitat types.

b. Attendance at a Tree Hazard Identification training course to train personnel to identify/evaluate tree defects, use the rating system, and recommend mitigation action; development and use of a detailed defect/hazard diagnostic key.

c. Attendance at arboriculture workshops where tree care, hazard treatment procedures and equipment use are taught; pest management seminars including insect and disease identification;

For employees involved in removal or limbing:

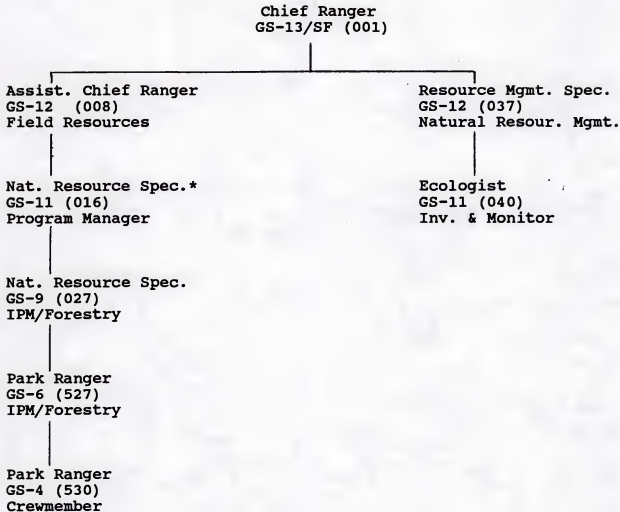
a. Technical training in chainsaw operations, including felling and climbing techniques, and equipment maintenance; certification may be required for chainsaw operators and fellers in some situations.

b. Safety training for protecting the public and other crewmembers while felling, bucking, limbing or removal operations are occurring.

c. Employees with chainsaw certification following completion of forest fire training course S-212 will be utilized in hazard tree removal.

The Natural Resource Specialist (Field Resources) will be responsible for developing programs to enhance staff expertise and coordinating training. This may be done by utilizing consultants, cooperative opportunities with other agencies or arranging specific training courses.

STAFFING CHART
RESOURCES DIVISION 1994
Hazard Tree Program



*Hazard Tree Team Leader

APPENDIX A -DEFINITIONS

Human-use area - Any park area that has been developed specifically for human use. This includes regularly maintained trails, roads, visitor facilities, residences and work areas. The undeveloped, off-trail/road areas of the park are not included.

Tree hazard - A tree or portion of a tree that has common detectable defects that sufficiently weaken a tree so that it is in imminent danger of falling in a human-use area and causing damage to a person or object.

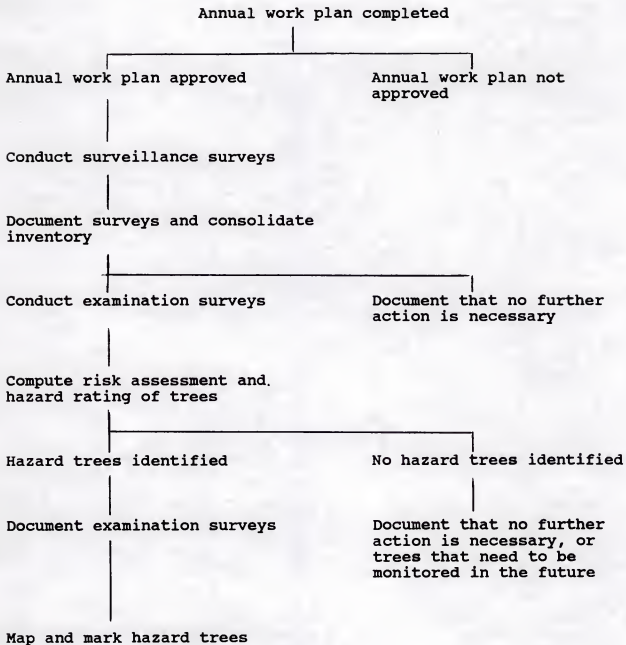
Defect - Any detectable character of a tree that may detract from the normal growth of the tree. Examples include irregular growth patterns, disease, rot, and death of the tree or portion of the tree. A defect may be natural or human caused. Natural defects are recognized as part of the ecosystem and are not considered in a negative light.

Target - Any person(s) or property that may sustain injury or damage from falling trees.

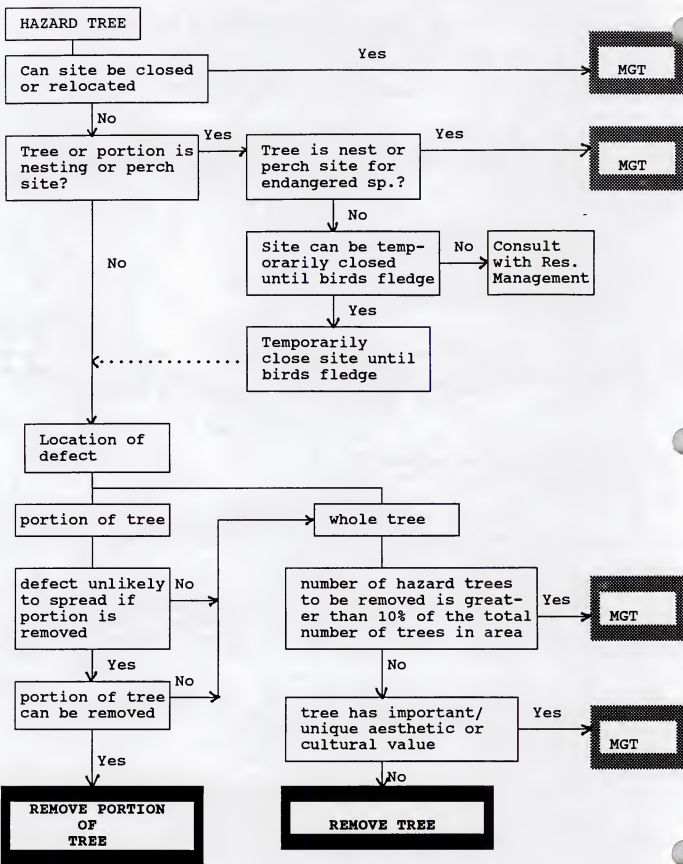
Hazard Rating System - A decision making process that is used to assign a value of risk to a tree based on the probability of tree failure, and the probability of extensive damage to a target. The cumulative point total falls within score ranges that define the condition.



APPENDIX B: HAZARD TREE MANAGEMENT DECISION TREE



(continued on next page)



APPENDIX C - TREE RATING CRITERIA USED IN DETAILED EXAMINATIONS

The criteria is a standard on which a decision is based to rate hazard trees using characteristic marks or traits of the tree. Criteria used to identify a hazard tree include observable defects in tree condition that result in high risk for failure, and potential of the tree to strike a target when it falls.

Each tree will be carefully surveyed for presence of defects. Trees with defects will be rated low, medium, high or very high (1-4), as to their likeliness of failure during the current season (USDI, 1991). Trees with no defects will automatically fall into the no hazard category.

The potential target will also be rated low, medium or high (1-3) according to the value of the structure and/or human-use levels.

A. Tree Evaluation Factors:

Examinations of the potential hazard trees identified in surveillance surveys must be done systematically. All observed defects are documented. Factors used to rate tree condition include:

1. External condition and appearance
2. Occurrence and extent of heart rot
3. Amount of sound wood remaining

External Condition

Johnson (1981) lists the following defects in order of importance to be noted on trees. These are observable conditions that can be documented during the examination survey, and evaluated.

1. Dead trees
2. Leaning trees
3. Root injuries
4. Crown injuries
5. Insect Activity

Weakness in the tree can result from physical injury, disease or insect activity. Two or more defects occurring together may sometimes render a tree hazardous when it might not be if it had only one defect. Examples include the combination of a sap rot and a heart rot, or one of a leaning tree with a large basal wound in line with the direction of lean. Other combinations are possible and should be looked for in the course of inspections.

Detailed information regarding types of diseases and tree species specific problems can be found in various publications (Hagle, et.al., 1987, Larson, 1984; Johnson, 1981; Hamilton and Edwards, 1976; and Wagener, 1963). It is recommended that the observer use these reports to be familiar with species specific problems. It is not the intent of this plan to replace technical references

used in field examinations. These field guides are important references to use in documenting tree condition. Since there is interest in the criteria used to predict tree failure, it may be helpful to list factors are indicators of high risk for failure.

Tree defects to watch for that are indicators of high failure potential are listed in table 1.

Table 1: Tree rating criteria to be used in examination surveys

LOCATION OF FAILURE	DEFECT	LOW FAILURE POTENTIAL	HIGH FAILURE POTENTIAL
WHOLE TREE FAILURE			Dead trees Leaning trees growing on sites with a high water table.
ROOT AND BUTT FAILURE	<p>► BUTT ROT (deciduous)</p> <p>► CANKERS (conifers except cedar and deciduous)</p> <p>► DWARF MISTLETOE (conifer except cedar)*</p> <p>► FOLIAGE (conifer except cedar)</p> <p>► FROST CRACKS (conifer except cedar)</p> <p>► FRUITING BODIES (conifers except cedar)</p> <p>► FRUITING BODIES (in cedar and deciduous trees)</p> <p>► HOLLOW BUTT (conifer except cedar)</p> <p>► HOLLOW BUTT (cedar)</p> <p>► HOLLOW BUTT (deciduous)</p> <p>► MYCELIUM (conifer except cedar)</p>	<p>Decay in butt confined to small, localized area. Decay extensive throughout the heartwood in the butt.</p> <p>Butt cankers with the bark still intact.</p> <p>Young dwarf mistletoe swelling in butt.</p> <p>Frost cracks with little or no associated advanced decay.</p> <p>Hollow butt if less than a quarter of the stem is affected.</p> <p>hollow butt provided less than a half of the circumference of the stem is affected.</p> <p>Hollow in butt confined to a small section of stem.</p> <p><i>Phellinus weirii</i> mycelium on the roots but no stain or decay in the butt.</p>	<p>Butt cankers affecting a major portion of the circumference of the stem and with much of the canker tissue dead.</p> <p>Dwarf mistletoe swellings in the butt, particularly if associated with advanced decay.</p> <p>Thin chlorotic foliage indicates a tree is dying as a result of root rot or other disease.</p> <p>Frost cracks with extensive associated advanced decay.</p> <p>Fruiting bodies on the butt of the tree, or on the ground around the tree.</p> <p>Fruiting bodies on lower bole.</p> <p>Hollow butt if a majority of the stem is decayed.</p> <p>Hollow butt with more than a half of the circumference of the stem affected and with significant advanced decay.</p> <p>Hollow in butt affecting a major portion of the circumference of stem.</p> <p><i>Phellinus weirii</i> mycelium on the roots and red-brown stain and/or decay in the butt.</p>

LOCATION OF FAILURE

ROOT AND BUTT FAILURE

DEFECT

- ▶ MYCELIUM (deciduous)
- ▶ PAVEMENT
- ▶ RESIN (conifer except cedar)
- ▶ ROOTS
- ▶ SOIL
- ▶ WOUNDS
- ▶ WOUNDS (conifers except cedar)
- ▶ WOUNDS (deciduous)

LOW FAILURE POTENTIAL

- Mycelium below the bark near the ground line confined to less than a half the circumference of the stem.
- Pavement, asphalt, over roots; not hazardous in itself but favors the development of hazardous conditions.
- Resin flow from the butt near the ground line, with less than a half the circumference of the stem affected.
- Few small roots severed or injured.
- Cracks or heaving in soil around tree indicating recent movement.
- Scar with little wood injury.
- Root and butt wounds less than 5 years old provided there is little advanced decay.
- Young small basal scars with little or no associated advanced decay.

HIGH FAILURE POTENTIAL

- Mycelium below the bark near the ground line affecting most of the circumference of the stem.
- Resin flow from the butt near the ground line, with most of the circumference of the stem affected. Mycelium fans below the bark.
- Most of the roots on one or more sides of the tree severed or badly damaged.
- Scar with the wood deeply gouged, possibly fractured.
- Root and butt wounds more than 10 years old and with extensive advanced decay.
- Basal scar with extensive associated advanced decay.

STEM FAILURES

- ▶ BURLS (deciduous)
- ▶ CANKERS (ponderosa pine)
- ▶ DWARF MISTLETOE (conifer except cedar)*
- ▶ FORKED STEMS (conifer except cedar)
- ▶ FORKS (cedar)
- ▶ FROST CRACKS
- ▶ FRUITING BODIES

- Burls or galls
- Cankers, horizontal, when low on trunks.
- Dwarf mistletoe stem canker with the bark still intact.
- Forked stems, one or both fork being of a small diameter.
- Forks and crooks.
- Frost cracks.
- One or two small fruiting bodies in the upper stem.

- Cankers, horizontal, when deep and above 16 feet from the ground.
- Dwarf mistletoe stem canker with more than a half the circumference dead.
- Large, long, and heavy forked stems joined part way up the stem. The crotch of the fork is at right angles to the direction of heaviest winds.
- Multiple fruiting bodies along length of stem.

LOCATION OF FAILURE

STEM FAILURE

DEFECT

LOW FAILURE POTENTIAL

HIGH FAILURE POTENTIAL

► HEART ROT
(deciduous)

Old lean, upper section of stem growing vertically.

Extensive heart rot, hollow stem

Recent lean, soil around tree cracked or having indicating recent movement.

► LEANING TREE **

Trees that have grown in a leaning position.

Leaning trees if (a) the lean has been caused by an outside force, or (b) an open wound with advanced decay and poor calluses is in line with the direction of lean.

► LEANING TREE (conifers) **

Leaning trees if the lean is extreme and the leverage great for the strength of the wood.

► LEANING TREE (deciduous) **

► TWIN STEMS (cedar)

Small twin stems.

Large twin stems joined part way up stem.

► WOUNDS

Scar with little wood injury

Scars with wood deeply gouged, possibly fractured.

► WOUNDS (conifer except cedar)

Scars less than 5 years old provided wood not deeply gouged.

Scars more than 5 years old and with extensive associated advanced decay.

► WOUNDS (deciduous)

Young small scars with little or no associated decay. Large scars affecting major portion of circumference of stem and with extensive associated advanced decay.

TOP AND BRANCHES

► BRANCH CROTCH (deciduous)

Sound crotch.

Split crotch.

► BROKEN TOPS

Broken tops with adjacent branches healthy.

Broken tops with adjacent branches unhealthy.

► CANKERS (conifer except cedar)

Top and branch cankers with the bark still intact.

Top cankers where most of the canker face is dead.

► DEAD BRANCHES (cedar and deciduous)

Small dead branches.

Large dead branches, especially if broken and lodged in other branches.

► DEAD TOPS (conifer except cedar)

Small tops, dead spike, on pines and Douglas-firs if old, without bark and deeply weathered.

Large tops and branches, dead on other species, or bark-covered on pines or Douglas-fir (includes dead volunteer tops).

► DECAY (deciduous)

Branches with little or no decay associated with crotch.

Extensive decay in stem and lower portion of large branches.

LOCATION OF FAILURE

TOP AND BRANCHES

DEFECT

► DWARF MISTLETOE (conifer except cedar)

► FORKED TOPS (conifer except cedar)

► FRUITING BODIES (conifer except cedar)

► MULTIPLE LEADERS

► SPIKE TOPS (cedar)

LOW FAILURE POTENTIAL

Small dwarf mistletoe brench and top swellings and witches' broom.

Small forked tops and crooks.

One or two small fruiting bodies in top of stem.

Small, live and thrifty volunteer tops.

Spike top not weakened by woodpeckers or decay.

HIGH FAILURE POTENTIAL

Large dwarf mistletoe, witches' brooms on branches.

Large forked tops.

Numerous fruiting bodies in top of stem.

Heavy U-shaped branches formed when side branches turn up to become leaders.

Spike top weakened by woodpeckers or decay.

* Main stem or trunk swellings, from stem infections by dwarfmistletoe when the host trees were young, may be quite prevalent on true firs. As long as the swelling remains alive, it does not weaken the trunk, but eventually the cambium in the oldest part of the swelling dies. The bark over the dead part soon becomes broken, creating an open canker. Decay usually develops in the dead wood, although its progress in different cankers is very variable. The eventual result is a weakening of the trunk of the host tree at the site of the canker. The status of the weakening cannot be judged closely from surface indications, but when the width of the dead face approaches half the circumference of the swelling, the trunk may break at the canker site under the stress of heavy wind or snow conditions. Most such breaks occur during winter storms, but they can take place at other times.

Open dwarfmistletoe cankers are sometimes found on the lower trunks of ponderosa pines, but the wood around them becomes heavily resin-infiltrated, protecting them from decay. They do not appear to contribute in any way to hazard.

** It is difficult to predict failure potential of leaning trees based on the angle of lean. The cause of the lean must be determined. A tree which has grown in a leaning position structurally compensates for the lean. In stress places, wood that is stronger than that in the vertical portions is formed. Such leaning trees have a low failure potential. Trees that lean because of root loosening caused by an outside force, such as heavy wind, flood waters, or a falling tree or snag have higher failure potential. These trees have not developed the stronger wood at these stress points. An old open fire wound may occasionally render a leaning tree hazardous if the wound is in line with the axis of strain from the lean and if advanced rot is present in the wood behind the wound.

MULTIPLE DEFECTS OR CONDITIONS

Two or more defects occurring together may sometimes render a tree hazardous when it might not be if it had only one defect. Examples include the combination of a sap rot and a heart rot, or one of a leaning tree with a large basal wound in line with the direction of lean. Other combinations are possible and should be looked for in the course of inspections.

B. Checking for Heart Rot

One of the most common defects to look for and assess in trees is heart rot or hollowness of the trunk resulting from it. Expect this defect particularly in trees bearing conks or showing old wounds, either open or closed. Occasionally, however, an old tree will be hollow with little outside evidence of heart rot. Keep in mind that a tree need not be large to be hollow.

The rate of recent diameter growth is a useful index of the probable safety of any tree with heart rot or hollowness. Trees that are making good growth will have thicker sapwood than those growing slowly and should be less likely to fail. The condition of callus growth around wounds is also of indicator value. If growth of the tree is good, callusing will be good and the bark over the callus will be thin and healthy in appearance. The crown will also be thrifty.

One test for heart rot or hollowness of the lower trunk consists in "sounding" the trunk by striking it sharply with the poll of an axe. If hollow or decayed and the surrounding wood is not too thick, the blow on the trunk will produce a hollow sound distinguishable from that produced when a solid trunk is struck in this manner.

For a more positive method of testing for hollowness, sample the lower trunk with an increment borer. If the borer breaks through into rot or a hollow resulting from the collapse of rot, the extracted core will give the thickness of the surrounding wall of solid wood at that point and also an opportunity to judge the rate of recent growth. [When heart rot is suspected, a increment core will be extracted to determine the extent of the rot and the thickness of sound wood so that the hazard level can be determined. See 'judging the hazard' section below.]

C. Amount of Sound Wood Remaining

As mentioned above, the presence of any of the listed defects does not automatically constitute a hazard. Many trees are sound even though they may be hollow. The extent of tree weakening must be determined in order to determine the potential of failure.

In order to determine the strength of a tree with heart rot, an increment core is needed. A tree with heart rot may lose up to 70 percent of wood inside the bark without affecting its safety (Wagener, 1963). Table 1 gives the minimum thickness of sound wood needed to maintain various diameters of trees.

Table 1. Minimum safe standard for defective trees applied as average thickness of outer sound wood of the trunk with center rot or hollow representing 70 percent of the total wood diameter, equivalent to one-third loss in strength. From Wagener, 1963.

Diameter of tree inside bark (inches)	Thickness of sound wood (inches)
16	2.5
20	3.0
24	3.5
28	4.0
32	4.5
36	5.5
40	6.0
44	6.5
48	7.0
52	8.0
56	8.5
60	9.0
64	9.5
68	10.0

APPENDIX D

DETERMINATION THE PROBABILITY THAT A TREE WILL HIT A TARGET

Determination of the probability that a tree will hit a target is based on the lean of the tree, width of the target, and the distance the tree is from the target. Using the angle within striking distance tables, the probability levels can be determine using the following steps.

1. Does the tree have a structurally defective lean?
 - no.....use Table A
go to step 2
 - yes-Does the tree lean toward the target?
 - no.....low probability
 - yes.....use Table B
go to step 2
2. Find the maximum width of the structure across the top row.
3. Follow the maximum width column down to the distance the tree is from the object.
4. Determine where the angle falls in relation to the probability level lines:
 - below the single line.....low probability
 - between the single and double lines..medium probability
 - above the double line.....high probability

Assumptions of the tables:

The tree is at the center of the width of the target and it would fall perpendicular to the target. For trees which this is not the case, the table will slightly overestimate the striking angles and resultant probability level.

The tree's height equals or exceeds the distance from the building.

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

		TARGET WIDTH																
		1	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	
F R O O M	T A R G E T	1	53	107	169	172	174	175	176	177	177	177	178	178	178	178	178	178
		5	11	90	127	143	152	157	161	164	166	167	169	170	170	171	172	172
		10	6	53	90	113	127	136	143	148	152	155	157	159	161	163	164	165
		15	4	37	67	90	106	118	127	134	139	143	147	149	152	154	156	157
		20	3	28	53	74	90	103	113	121	127	132	136	140	143	146	148	150
		25	2	23	44	62	77	90	100	109	116	122	127	131	135	138	141	143
		30	2	19	37	53	67	80	90	99	106	113	118	123	127	130	134	136
		35	2	16	32	46	59	71	81	90	98	104	110	115	119	123	127	130
		40	1	14	28	41	53	64	74	82	90	97	103	108	113	117	121	124
		45	1	13	25	37	48	58	67	76	83	90	96	101	106	111	115	118
		50	1	11	23	33	44	53	62	70	77	84	90	95	100	105	109	113
		55	1	10	21	31	40	49	57	65	72	79	85	90	95	100	104	107
		60	1	10	19	28	37	45	53	61	67	74	80	85	90	95	99	103
		65	1	9	17	26	34	42	50	57	63	69	75	80	85	90	94	98
		70	1	8	16	24	32	39	46	53	59	65	71	76	81	86	90	94
		75	1	8	15	23	30	37	44	50	56	62	67	73	77	82	86	90
		80	1	7	14	21	28	35	41	47	53	59	64	69	74	78	82	86
		85	1	7	13	20	26	33	39	45	50	56	61	66	70	75	79	83
		90	1	6	13	19	25	31	37	43	48	53	58	63	67	72	76	80
		95	1	6	12	18	24	29	35	40	46	51	56	60	65	69	73	77
100	1	6	11	17	23	28	33	39	44	48	53	58	62	66	70	74		
105	1	5	11	16	22	27	32	37	42	46	51	55	59	64	67	71		
110	1	5	10	16	21	26	31	35	40	44	49	53	57	61	65	69		
115	0	5	10	15	20	25	29	34	38	43	47	51	55	59	63	66		
120	0	5	10	14	19	24	28	33	37	41	45	49	53	57	61	64		
125	0	5	9	14	18	23	27	31	35	40	44	47	51	55	58	62		
130	0	4	9	13	17	22	26	30	34	38	42	46	50	53	57	60		
135	0	4	8	13	17	21	25	29	33	37	41	44	48	51	55	58		
140	0	4	8	12	16	20	24	28	32	36	39	43	46	50	53	56		
145	0	4	8	12	16	20	23	27	31	34	38	42	45	48	52	55		
150	0	4	8	11	15	19	23	26	30	33	37	40	44	47	50	53		
155	0	4	7	11	15	18	22	25	29	32	36	39	42	46	49	52		
160	0	4	7	11	14	18	21	25	28	31	35	38	41	44	47	50		
165	0	3	7	10	14	17	21	24	27	31	34	37	40	43	46	49		
170	0	3	7	10	13	17	20	23	26	30	33	36	39	42	45	48		
175	0	3	7	10	13	16	19	23	26	29	32	35	38	41	44	46		
180	0	3	6	10	13	16	19	22	25	28	31	34	37	40	43	45		
185	0	3	6	9	12	15	18	21	24	27	30	33	36	39	41	44		
190	0	3	6	9	12	15	18	21	24	27	29	32	35	38	40	43		
195	0	3	6	9	12	15	17	20	23	26	29	32	34	37	39	42		
200	0	3	6	9	11	14	17	20	23	25	28	31	33	36	39	41		

DISTANCE
FROM
TARGET

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

		TARGET WIDTH															
		160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	
DISTANCE FROM TARGET	1	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	
	5	173	173	174	174	174	175	175	175	175	175	176	176	176	176	176	
	10	166	167	167	168	169	169	170	170	170	171	171	172	172	172	172	
	15	159	160	161	162	163	164	164	165	166	166	167	167	168	168	169	
	20	152	154	155	156	157	158	159	160	161	162	163	163	164	164	165	
	25	145	147	149	151	152	153	154	155	156	157	158	159	160	160	161	
	30	139	141	143	145	147	148	149	151	152	153	154	155	156	157	157	
	35	133	135	137	140	141	143	145	146	147	149	150	151	152	153	154	
	40	127	130	132	134	136	138	140	142	143	145	146	147	148	149	150	
	45	121	124	127	129	132	134	136	137	139	140	142	143	144	146	147	
	50	116	119	122	124	127	129	131	133	135	136	138	139	141	142	143	
	55	111	114	117	120	122	125	127	129	131	133	134	136	137	138	140	
	60	106	110	113	115	118	121	123	125	127	129	130	132	134	135	136	
	65	102	105	108	111	114	116	119	121	123	125	127	129	130	132	133	
	70	98	101	104	107	110	113	115	117	119	122	123	125	127	128	130	
	75	94	97	100	103	106	109	111	114	116	118	120	122	124	125	127	
	80	90	93	97	100	103	105	108	110	113	115	117	119	121	122	124	
	85	87	90	93	96	99	102	105	107	109	112	114	116	117	119	121	
	90	83	87	90	93	96	99	101	104	106	108	111	113	115	116	118	
	95	80	84	87	90	93	96	98	101	103	106	108	110	112	114	115	
100	77	81	84	87	90	93	95	98	100	103	105	107	109	111	113		
105	75	78	81	84	87	90	93	95	98	100	102	104	106	108	110		
110	72	75	79	82	85	87	90	93	95	97	100	102	104	106	107		
115	70	73	76	79	82	85	87	90	92	95	97	99	101	103	105		
120	67	71	74	77	80	82	85	88	90	92	95	97	99	101	103		
125	65 <td>68</td> <td>72</td> <td>74</td> <td>77</td> <td>80</td> <td>83</td> <td>85</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td> <td>96</td> <td>98</td> <td>100</td>	68	72	74	77	80	83	85	88	90	92	94	96	98	100		
130	63 <td>66</td> <td>69</td> <td>72</td> <td>75</td> <td>78</td> <td>80</td> <td>83</td> <td>85</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td> <td>96</td> <td>98</td>	66	69	72	75	78	80	83	85	88	90	92	94	96	98		
135	61 <td>64</td> <td>67</td> <td>70</td> <td>73</td> <td>76</td> <td>78</td> <td>81</td> <td>83</td> <td>86</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td> <td>96</td>	64	67	70	73	76	78	81	83	86	88	90	92	94	96		
140	59 <td>63</td> <td>65</td> <td>68</td> <td>71</td> <td>74</td> <td>76</td> <td>79</td> <td>81</td> <td>84</td> <td>86</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td>	63	65	68	71	74	76	79	81	84	86	88	90	92	94		
145	58 <td>61</td> <td>64</td> <td>66</td> <td>69</td> <td>72</td> <td>74</td> <td>77</td> <td>79</td> <td>82</td> <td>84</td> <td>86</td> <td>88</td> <td>90</td> <td>92</td>	61	64	66	69	72	74	77	79	82	84	86	88	90	92		
150	56 <td>59</td> <td>62</td> <td>65</td> <td>67</td> <td>70</td> <td>73</td> <td>75</td> <td>77</td> <td>80</td> <td>82</td> <td>84</td> <td>86</td> <td>88</td> <td>90</td>	59	62	65	67	70	73	75	77	80	82	84	86	88	90		
155	55 <td>57</td> <td>60</td> <td>63</td> <td>66</td> <td>68</td> <td>71</td> <td>73</td> <td>75</td> <td>78</td> <td>80</td> <td>82</td> <td>84</td> <td>86</td> <td>88</td>	57	60	63	66	68	71	73	75	78	80	82	84	86	88		
160	53 <td>56</td> <td>59</td> <td>61</td> <td>64</td> <td>67</td> <td>69</td> <td>71</td> <td>74</td> <td>76</td> <td>78</td> <td>80</td> <td>82</td> <td>84</td> <td>86</td>	56	59	61	64	67	69	71	74	76	78	80	82	84	86		
165	52 <td>55</td> <td>57</td> <td>60</td> <td>62</td> <td>65</td> <td>67</td> <td>70</td> <td>72</td> <td>74</td> <td>76</td> <td>79</td> <td>81</td> <td>83</td> <td>85</td>	55	57	60	62	65	67	70	72	74	76	79	81	83	85		
170	50 <td>53<td>56<td>58</td><td>61</td><td>63</td><td>66</td><td>68</td><td>70</td><td>73</td><td>75</td><td>77</td><td>79</td><td>81</td><td>83</td></td></td>	53 <td>56<td>58</td><td>61</td><td>63</td><td>66</td><td>68</td><td>70</td><td>73</td><td>75</td><td>77</td><td>79</td><td>81</td><td>83</td></td>	56 <td>58</td> <td>61</td> <td>63</td> <td>66</td> <td>68</td> <td>70</td> <td>73</td> <td>75</td> <td>77</td> <td>79</td> <td>81</td> <td>83</td>	58	61	63	66	68	70	73	75	77	79	81	83		
175	49 <td>52<td>54<td>57<td>59</td><td>62</td><td>64</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td><td>79</td><td>81</td></td></td></td>	52 <td>54<td>57<td>59</td><td>62</td><td>64</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td><td>79</td><td>81</td></td></td>	54 <td>57<td>59</td><td>62</td><td>64</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td><td>79</td><td>81</td></td>	57 <td>59</td> <td>62</td> <td>64</td> <td>67</td> <td>69</td> <td>71</td> <td>73</td> <td>75</td> <td>77</td> <td>79</td> <td>81</td>	59	62	64	67	69	71	73	75	77	79	81		
180	48 <td>51<td>53<td>56<td>58</td><td>61</td><td>63</td><td>65</td><td>67</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td><td>80</td></td></td></td>	51 <td>53<td>56<td>58</td><td>61</td><td>63</td><td>65</td><td>67</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td><td>80</td></td></td>	53 <td>56<td>58</td><td>61</td><td>63</td><td>65</td><td>67</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td><td>80</td></td>	56 <td>58</td> <td>61</td> <td>63</td> <td>65</td> <td>67</td> <td>70</td> <td>72</td> <td>74</td> <td>76</td> <td>78</td> <td>80</td>	58	61	63	65	67	70	72	74	76	78	80		
185	47 <td>49<td>52<td>54<td>57<td>59</td><td>61</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td></td></td></td></td>	49 <td>52<td>54<td>57<td>59</td><td>61</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td></td></td></td>	52 <td>54<td>57<td>59</td><td>61</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td></td></td>	54 <td>57<td>59</td><td>61</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td><td>76</td><td>78</td></td>	57 <td>59</td> <td>61</td> <td>64</td> <td>66</td> <td>68</td> <td>70</td> <td>72</td> <td>74</td> <td>76</td> <td>78</td>	59	61	64	66	68	70	72	74	76	78		
190	46 <td>48<td>51<td>53<td>56<td>58</td><td>60</td><td>62</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td></td></td></td></td>	48 <td>51<td>53<td>56<td>58</td><td>60</td><td>62</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td></td></td></td>	51 <td>53<td>56<td>58</td><td>60</td><td>62</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td></td></td>	53 <td>56<td>58</td><td>60</td><td>62</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td><td>77</td></td>	56 <td>58</td> <td>60</td> <td>62</td> <td>65</td> <td>67</td> <td>69</td> <td>71</td> <td>73</td> <td>75</td> <td>77</td>	58	60	62	65	67	69	71	73	75	77		
195	45 <td>47<td>50<td>52<td>54<td>57<td>59</td><td>61</td><td>63</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td></td></td></td></td></td>	47 <td>50<td>52<td>54<td>57<td>59</td><td>61</td><td>63</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td></td></td></td></td>	50 <td>52<td>54<td>57<td>59</td><td>61</td><td>63</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td></td></td></td>	52 <td>54<td>57<td>59</td><td>61</td><td>63</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td></td></td>	54 <td>57<td>59</td><td>61</td><td>63</td><td>65</td><td>67</td><td>69</td><td>71</td><td>73</td><td>75</td></td>	57 <td>59</td> <td>61</td> <td>63</td> <td>65</td> <td>67</td> <td>69</td> <td>71</td> <td>73</td> <td>75</td>	59	61	63	65	67	69	71	73	75		
200	44 <td>46<td>48<td>51<td>53<td>55<td>58</td><td>60</td><td>62</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td></td></td></td></td></td>	46 <td>48<td>51<td>53<td>55<td>58</td><td>60</td><td>62</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td></td></td></td></td>	48 <td>51<td>53<td>55<td>58</td><td>60</td><td>62</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td></td></td></td>	51 <td>53<td>55<td>58</td><td>60</td><td>62</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td></td></td>	53 <td>55<td>58</td><td>60</td><td>62</td><td>64</td><td>66</td><td>68</td><td>70</td><td>72</td><td>74</td></td>	55 <td>58</td> <td>60</td> <td>62</td> <td>64</td> <td>66</td> <td>68</td> <td>70</td> <td>72</td> <td>74</td>	58	60	62	64	66	68	70	72	74		

DISTANCE
FROM
TARGET

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

TARGET WIDTH																	
	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450		
1	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	
5	176	176	177	177	177	177	177	177	177	177	177	177	177	177	177	177	
10	173	173	173	173	173	174	174	174	174	174	174	175	175	175	175	175	
15	169	169	170	170	170	170	171	171	171	171	172	172	172	172	172	172	
20	165	166	166	167	167	167	168	168	168	169	169	169	169	169	170	170	
25	162	162	163	163	164	164	165	165	165	166	166	166	167	167	167	167	
30	158	159	159	160	161	161	162	162	163	163	163	164	164	164	165	165	
35	155	155	156	157	157	158	159	159	160	160	161	161	162	162	162	162	
40	151	152	153	154	154	155	156	156	157	157	158	158	159	159	160	160	
45	148	149	149	150	151	152	153	153	154	155	155	156	156	157	157	157	
50	144	145	146	147	148	149	150	151	151	152	153	153	154	154	155	155	
55	141	142	143	144	145	146	147	148	148	149	150	151	151	152	153	153	
60	138	139	140	141	142	143	144	145	146	147	147	148	149	149	150	150	
65	134	136	137	138	139	140	141	142	143	144	145	146	146	147	148	148	
70	131	133	134	135	136	137	139	140	141	141	142	143	144	145	145	145	
75	128	130	131	132	134	135	136	137	138	139	140	141	142	142	143	143	
80	125	127	128	130	131	132	133	134	135	136	137	138	139	140	141	141	
85	123	124	125	127	128	129	131	132	133	134	135	136	137	138	139	139	
90	120	121	123	124	126	127	128	129	130	132	133	134	135	136	136	136	
95	117	119	120	122	123	124	126	127	128	129	130	131	132	133	134	134	
100	114	116	118	119	121	122	123	124	126	127	128	129	130	131	132	132	
105	112	113	115	117	118	119	121	122	123	125	126	127	128	129	130	130	
110	109	111	113	114	116	117	119	120	121	122	124	125	126	127	128	128	
115	107	109	110	112	113	115	116	118	119	120	121	123	124	125	126	126	
120	105	106	108	110	111	113	114	115	117	118	119	121	122	123	124	124	
125	102	104	106	107	109	110	112	113	115	116	117	118	120	121	122	122	
130	100	102	104	105	107	108	110	111	113	114	115	116	118	119	120	120	
135	98	100	101	103	105	106	108	109	111	112	113	115	116	117	118	118	
140	96	98	99	101	103	104	106	107	109	110	111	113	114	115	116	116	
145	94	96	97	99	101	102	104	105	107	108	109	111	112	113	114	114	
150	92	94	95	97	99	100	102	103	105	106	108	109	110	111	113	113	
155	90	92	94	95	97	99	100	102	103	104	106	107	108	110	111	111	
160	88	90	92	93	95	97	98	100	101	103	104	105	107	108	109	109	
165	86	88	90	92	93	95	97	98	100	101	102	104	105	106	107	107	
170	85	87	88	90	92	93	95	96	98	99	101	102	103	105	106	106	
175	83	85	87	88	90	92	93	95	96	98	99	100	102	103	104	104	
180	81	83	85	87	88	90	92	93	95	96	97	99	100	101	103	103	
185	80	82	83	85	87	88	90	92	93	94	96	97	99	100	101	101	
190	78	80	82	84	85	87	88	90	91	93	94	96	97	98	100	100	
195	77	79	80	82	84	85	87	89	90	91	93	94	96	97	98	98	
200	76	77	79	81	82	84	86	87	89	90	91	93	94	95	97	97	
D I S T A N C E F R O M T A R G E T																	

DISTANCE FROM TARGET

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

DISTANCE FROM TARGET	TARGET WIDTH															
	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	
1	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	
5	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	
10	175	175	175	175	175	176	176	176	176	176	176	176	176	176	176	
15	173	173	173	173	173	173	173	174	174	174	174	174	174	174	174	
20	170	170	170	171	171	171	171	171	172	172	172	172	172	172	172	
25	168	168	168	168	169	169	169	169	169	170	170	170	170	170	170	
30	165	165	166	166	166	167	167	167	167	168	168	168	168	168	169	
35	163	163	163	164	164	164	165	165	165	165	166	166	166	166	167	
40	160	161	161	161	162	162	163	163	163	163	164	164	164	165	165	
45	158	158	159	159	160	160	160	161	161	161	162	162	162	163	163	
50	155	156	156	157	157	158	158	159	159	159	160	160	160	161	161	
55	153	154	154	155	155	156	156	157	157	157	158	158	159	159	159	
60	151	151	152	152	153	154	154	155	155	155	156	156	157	157	157	
65	148	149	150	150	151	151	152	152	153	153	154	154	155	155	156	
70	146	147	147	148	149	149	150	150	151	151	152	152	153	153	154	
75	144	145	145	146	147	147	148	148	149	149	150	151	151	151	152	
80	142	142	143	144	145	145	146	146	147	148	148	149	149	150	150	
85	139	140	141	142	142	143	144	144	145	146	146	147	147	148	148	
90	137	138	139	140	140	141	142	142	143	144	144	145	146	146	147	
95	135	136	137	138	138	139	140	141	141	142	143	143	144	144	145	
100	133	134	135	136	136	137	138	139	139	140	141	141	142	143	143	
105	131	132	133	134	134	135	136	137	137	138	139	140	140	141	141	
110	129	130	131	132	133	133	134	135	136	136	137	138	138	139	140	
115	127	128	129	130	131	131	132	133	134	135	135	136	137	137	138	
120	125	126	127	128	129	130	130	131	132	133	134	134	135	136	136	
125	123	124	125	126	127	128	129	129	130	131	132	133	133	134	135	
130	121	122	123	124	125	126	127	128	129	129	130	131	132	132	133	
135	119	120	121	122	123	124	125	126	127	128	129	129	130	131	132	
140	117	118	119	121	122	122	123	124	125	126	127	128	128	129	130	
145	116	117	118	119	120	121	122	123	124	124	125	126	127	128	128	
150	114	115	116	117	118	119	120	121	122	123	124	124	125	126	127	
155	112	113	114	115	116	117	118	119	120	121	122	123	124	125	125	
160	110	112	113	114	115	116	117	118	119	120	121	121	122	123	124	
165	109	110	111	112	113	114	115	116	117	118	119	120	121	122	122	
170	107	108	109	110	112	113	114	115	116	117	118	119	120	121	121	
175	105	107	108	109	110	111	112	113	114	115	116	117	118	119	119	
180	104	105	106	107	108	110	111	112	113	114	115	115	116	117	118	
185	102	104	105	106	107	108	109	110	111	112	113	114	115	116	117	
190	101	102	103	104	106	107	108	109	110	111	112	113	114	114	115	
195	99	101	102	103	104	105	106	107	108	109	110	111	112	113	114	
200	98	99	100	102	103	104	105	106	107	108	109	110	111	112	113	

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

DISTANCE FROM TARGET	TARGET WIDTH															
	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750	
1	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
5	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178
10	176	176	176	176	176	177	177	177	177	177	177	177	177	177	177	177
15	174	174	175	175	175	175	175	175	175	175	175	175	175	175	175	175
20	172	173	173	173	173	173	173	173	173	173	174	174	174	174	174	174
25	171	171	171	171	171	171	171	172	172	172	172	172	172	172	172	172
30	169	169	169	169	169	170	170	170	170	170	170	170	171	171	171	171
35	167	167	167	168	168	168	168	168	168	169	169	169	169	169	169	169
40	165	165	166	166	166	166	166	167	167	167	167	167	167	168	168	168
45	163	163	164	164	164	164	165	165	165	165	166	166	166	166	166	166
50	161	162	162	162	163	163	163	163	164	164	164	164	164	165	165	165
55	160	160	160	160	161	161	161	162	162	162	162	163	163	163	163	163
60	158	158	158	159	159	159	160	160	160	161	161	161	161	162	162	162
65	156	156	157	157	157	158	158	158	159	159	159	160	160	160	160	160
70	154	155	155	155	156	156	156	157	157	157	158	158	158	159	159	159
75	152	153	153	154	154	154	155	155	155	156	156	156	157	157	157	157
80	151	151	151	152	152	153	153	154	154	154	155	155	155	156	156	156
85	149	149	150	150	151	151	152	152	152	153	153	153	154	154	154	154
90	147	148	148	149	149	149	150	150	151	151	152	152	152	153	153	153
95	145	146	146	147	147	148	148	149	149	150	150	150	151	151	151	152
100	144	144	145	145	146	146	147	147	148	148	149	149	149	150	150	150
105	142	143	143	144	144	145	145	146	146	147	147	147	148	148	149	149
110	140	141	142	142	143	143	144	144	145	145	146	146	146	147	147	147
115	139	139	140	140	141	142	142	143	143	144	144	145	145	146	146	146
120	137	138	138	139	139	140	141	141	142	142	143	143	144	144	145	145
125	135	136	137	137	138	139	139	140	140	141	141	142	142	143	143	143
130	134	134	135	136	136	137	138	138	139	139	140	140	141	141	141	142
135	132	133	134	134	135	136	136	137	137	138	138	139	139	140	140	140
140	131	131	132	133	133	134	135	135	136	136	137	137	138	138	139	139
145	129	130	131	131	132	133	133	134	134	135	136	136	137	137	138	138
150	128	128	129	130	130	131	132	132	133	134	134	135	135	136	136	136
155	126	127	128	128	129	130	130	131	132	132	133	133	134	135	135	135
160	125	125	126	127	128	128	129	130	130	131	131	132	133	133	134	134
165	123	124	125	125	126	127	128	128	129	130	130	131	131	132	133	133
170	122	123	123	124	125	125	126	127	128	128	129	129	130	131	131	131
175	120	121	122	123	123	124	125	126	126	127	128	128	129	129	130	130
180	119	120	121	121	122	123	124	124	125	126	126	127	127	128	128	129
185	118	118	119	120	121	121	122	123	124	124	125	126	126	127	127	127
190	116	117	118	119	119	120	121	122	122	123	124	124	125	126	126	126
195	115	116	116	117	118	119	120	120	121	122	122	123	124	124	125	125
200	113	114	115	116	117	118	118	119	120	121	121	122	123	123	124	124

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

		TARGET WIDTH																
		760	770	780	790	800	810	820	830	840	850	860	870	880	890	900		
TARGET FIBER MODULUS	1	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	
	5	178	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	
	10	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	
	15	175	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	
	20	174	174	174	174	174	174	174	174	174	175	175	175	175	175	175	175	
	25	172	173	173	173	173	173	173	173	173	173	173	173	173	173	174	174	
	30	171	171	171	171	171	172	172	172	172	172	172	172	172	172	172	172	
	35	169	170	170	170	170	170	170	170	170	171	171	171	171	171	171	171	
	40	168	168	168	168	169	169	169	169	169	169	169	169	169	170	170	170	
	45	166	167	167	167	167	167	167	167	168	168	168	168	168	168	168	169	
	50	165	165	165	166	166	166	166	166	166	166	167	167	167	167	167	167	
	55	164	164	164	164	164	165	165	165	165	165	165	165	166	166	166	166	
	60	162	162	163	163	163	163	163	164	164	164	164	164	164	164	165	165	
	65	161	161	161	161	162	162	162	162	162	162	163	163	163	163	163	164	
	70	159	159	160	160	160	160	161	161	161	161	161	162	162	162	162	162	
	75	158	158	158	158	159	159	159	160	160	160	160	160	160	161	161	161	
	80	156	157	157	157	157	158	158	158	158	159	159	159	159	159	160	160	
	85	155	155	155	156	156	156	157	157	157	157	158	158	158	158	159	159	
	90	153	154	154	154	155	155	155	156	156	156	156	157	157	157	157	157	
	95	152	152	153	153	153	154	154	154	155	155	155	155	155	156	156	156	
100	151	151	151	152	152	152	153	153	153	154	154	154	154	154	155	155		
105	149	149	150	150	151	151	151	152	152	152	153	153	153	153	154	154		
110	148	148	148	149	149	150	150	150	151	151	151	152	152	152	153	153		
115	146	147	147	148	148	148	148	149	149	149	150	150	150	151	151	151		
120	145	145	146	146	147	147	147	148	148	148	149	149	149	150	150	150		
125	144	144	144	145	145	146	146	146	147	147	148	148	148	149	149	149		
130	142	143	143	144	144	144	145	145	146	146	146	147	147	147	148	148		
135	141	141	142	142	143	143	144	144	144	145	145	146	146	146	147	147		
140	140	140	141	141	141	142	142	143	143	144	144	144	145	145	145	146		
145	138	139	139	140	140	140	141	141	141	142	142	143	143	144	144	144		
150	137	137	138	138	139	139	140	140	141	141	142	142	142	143	143	143		
155	136	136	137	137	138	138	139	139	139	140	140	141	141	142	142	142		
160	134	135	135	136	136	137	137	138	138	139	139	140	140	140	141	141		
165	133	134	134	135	135	136	136	137	137	138	138	138	139	139	140	140		
170	132	132	133	133	134	134	135	135	136	136	137	137	138	138	139	139		
175	131	131	132	132	133	133	134	134	135	135	136	136	137	137	137	137		
180	129	130	130	131	132	132	133	133	134	134	135	135	136	136	136	136		
185	128	129	129	130	130	131	131	132	132	133	133	134	134	135	135	135		
190	127	127	128	129	129	130	130	131	131	132	132	133	133	134	134	134		
195	126	126	127	127	128	129	129	130	130	131	131	132	132	133	133	133		
200	124	125	126	126	127	127	128	129	129	130	130	131	131	132	132	132		

DISTANCE
FROM
TARGET

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

		TARGET WIDTH														
		910	920	930	940	950	960	970	980	990	1000	1010	1020	1030	1040	1050
DISTANCE FROM TARGET	1	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
	5	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179
	10	177	178	178	178	178	178	178	178	178	178	178	178	178	178	178
	15	176	176	176	176	176	176	176	176	177	177	177	177	177	177	177
	20	175	175	175	175	175	175	175	175	175	175	175	176	176	176	176
	25	174	174	174	174	174	174	174	174	174	174	174	174	174	174	175
	30	172	173	173	173	173	173	173	173	173	173	173	173	173	173	173
	35	171	171	171	171	172	172	172	172	172	172	172	172	172	172	172
	40	170	170	170	170	170	170	171	171	171	171	171	171	171	171	171
	45	169	169	169	169	169	169	169	170	170	170	170	170	170	170	170
	50	167	168	168	168	168	168	168	168	168	169	169	169	169	169	169
	55	166	166	167	167	167	167	167	167	167	167	168	168	168	168	168
	60	165	165	165	165	166	166	166	166	166	166	166	167	167	167	167
	65	164	164	164	164	164	165	165	165	165	165	165	165	166	166	166
	70	163	163	163	163	163	163	164	164	164	164	164	164	164	165	165
	75	161	161	162	162	162	162	162	163	163	163	163	163	163	163	164
	80	160	160	160	161	161	161	161	161	162	162	162	162	162	162	163
	85	159	159	159	159	160	160	160	160	160	161	161	161	161	161	161
	90	158	158	158	158	159	159	159	159	159	159	160	160	160	160	160
	95	156	157	157	157	157	158	158	158	158	158	159	159	159	159	159
100	155	155	156	156	156	156	157	157	157	157	157	158	158	158	158	
105	154	154	155	155	155	155	155	156	156	156	156	157	157	157	157	
110	153	153	153	154	154	154	154	154	155	155	155	155	156	156	156	
115	152	152	152	153	153	153	153	153	154	154	154	154	155	155	155	
120	150	151	151	151	152	152	152	152	153	153	153	153	154	154	154	
125	149	150	150	150	151	151	151	151	151	152	152	152	152	153	153	
130	148	148	149	149	149	150	150	150	150	151	151	151	151	152	152	
135	147	147	148	148	148	149	149	149	149	150	150	150	150	151	151	
140	146	146	146	147	147	147	148	148	148	149	149	149	149	150	150	
145	145	145	145	146	146	146	147	147	147	148	148	148	148	149	149	
150	144	144	144	145	145	145	146	146	146	147	147	147	147	148	148	
155	142	143	143	143	144	144	145	145	145	146	146	146	146	146	147	
160	141	142	142	142	143	143	143	144	144	145	145	145	145	146	146	
165	140	141	141	141	142	142	142	143	143	143	144	144	144	145	145	
170	139	139	140	140	141	141	141	142	142	142	143	143	143	144	144	
175	138	138	139	139	140	140	140	141	141	141	142	142	142	143	143	
180	137	137	138	138	138	139	139	140	140	140	141	141	141	142	142	
185	136	136	137	137	137	138	138	139	139	139	140	140	140	141	141	
190	135	135	136	136	136	137	137	138	138	138	139	139	139	140	140	
195	134	134	134	135	135	136	136	137	137	137	138	138	138	139	139	
200	133	133	133	134	134	135	135	136	136	136	137	137	137	138	138	

DISTANCE FROM TARGET

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

DISTANCE FROM TARGET	TARGET WIDTH															
	1060	1070	1080	1090	1100	1110	1120	1130	1140	1150	1160	1170	1180	1190	1200	
1	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
5	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179
10	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178
15	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177
20	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
25	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175
30	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174
35	172	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173
40	171	171	172	172	172	172	172	172	172	172	172	172	172	172	172	172
45	170	170	170	171	171	171	171	171	171	171	171	171	171	171	171	171
50	169	169	169	170	170	170	170	170	170	170	170	170	170	170	170	170
55	168	168	168	168	169	169	169	169	169	169	169	169	169	169	169	170
60	167	167	167	167	168	168	168	168	168	168	168	168	168	168	168	169
65	166	166	166	166	167	167	167	167	167	167	167	167	167	167	168	168
70	165	165	165	165	165	166	166	166	166	166	166	166	166	166	167	167
75	164	164	164	164	164	165	165	165	165	165	165	165	165	165	166	166
80	163	163	163	163	163	164	164	164	164	164	164	164	164	165	165	165
85	162	162	162	162	162	163	163	163	163	163	163	163	163	163	164	164
90	161	161	161	161	161	162	162	162	162	162	162	162	163	163	163	163
95	160	160	160	160	160	161	161	161	161	161	161	161	162	162	162	162
100	159	159	159	159	159	160	160	160	160	160	160	160	161	161	161	161
105	158	158	158	158	158	159	159	159	159	159	159	159	160	160	160	160
110	157	157	157	157	157	158	158	158	158	158	158	159	159	159	159	159
115	156	156	156	156	156	157	157	157	157	157	157	158	158	158	158	158
120	154	155	155	155	155	156	156	156	156	156	156	157	157	157	157	157
125	153	154	154	154	154	155	155	155	155	155	155	156	156	156	156	156
130	152	153	153	153	153	154	154	154	154	154	155	155	155	155	155	156
135	151	152	152	152	152	153	153	153	153	153	154	154	154	154	154	155
140	150	151	151	151	151	152	152	152	152	152	153	153	153	153	154	154
145	149	150	150	150	150	151	151	151	151	151	152	152	152	152	153	153
150	148	149	149	149	149	150	150	150	150	151	151	151	151	151	152	152
155	147	148	148	148	149	149	149	149	149	150	150	150	150	150	151	151
160	146	147	147	147	148	148	148	148	148	149	149	149	149	150	150	150
165	145	146	146	146	147	147	147	147	147	148	148	148	148	149	149	149
170	144	145	145	145	146	146	146	147	147	147	147	147	148	148	148	148
175	143	144	144	144	145	145	145	146	146	146	146	146	147	147	147	147
180	142	143	143	143	144	144	144	145	145	145	146	146	146	146	146	147
185	142	142	142	143	143	143	143	144	144	144	145	145	145	145	146	146
190	141	141	141	142	142	142	143	143	143	143	144	144	144	145	145	145
195	140	140	140	141	141	141	142	142	142	143	143	143	143	144	144	144
200	139	139	139	140	140	140	141	141	141	142	142	142	143	143	143	143

TABLE A FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITHOUT A LEAN

DISTANCE FROM TARGET	TARGET WIDTH																
	1210	1220	1230	1240	1250	1260	1270	1280	1290	1300	1310	1320	1330	1340	1350		
1	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
5	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179
10	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178
15	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177
20	176	176	176	176	176	176	176	176	176	176	177	177	177	177	177	177	177
25	175	175	175	175	175	175	175	176	176	176	176	176	176	176	176	176	176
30	174	174	174	174	175	175	175	175	175	175	175	175	175	175	175	175	175
35	173	173	173	174	174	174	174	174	174	174	174	174	174	174	174	174	174
40	172	172	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173
45	171	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172
50	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171	171	172
55	170	170	170	170	170	170	170	170	170	170	170	170	170	171	171	171	171
60	169	169	169	169	169	169	169	169	169	169	169	170	170	170	170	170	170
65	168	168	168	168	168	168	168	168	168	168	169	169	169	169	169	169	169
70	167	167	167	167	167	167	167	168	168	168	168	168	168	168	168	168	168
75	166	166	166	166	166	166	167	167	167	167	167	167	167	167	167	167	167
80	165	165	165	165	165	166	166	166	166	166	166	166	166	166	166	166	166
85	164	164	164	164	165	165	165	165	165	165	165	165	165	165	165	166	166
90	163	163	163	163	164	164	164	164	164	164	164	164	164	165	165	165	165
95	162	162	162	163	163	163	163	163	163	163	163	163	163	164	164	164	164
100	161	161	162	162	162	162	162	162	162	162	163	163	163	163	163	163	163
105	160	160	161	161	161	161	161	161	162	162	162	162	162	162	162	162	162
110	159	160	160	160	160	160	160	160	161	161	161	161	161	161	161	161	161
115	158	159	159	159	159	159	159	160	160	160	160	160	160	160	161	161	161
120	158	158	158	158	158	158	159	159	159	159	159	159	159	160	160	160	160
125	157	157	157	157	157	158	158	158	158	158	158	158	159	159	159	159	159
130	156	156	156	156	157	157	157	157	157	157	157	158	158	158	158	158	158
135	155	155	155	155	156	156	156	156	156	156	157	157	157	157	157	157	157
140	154	154	154	155	155	155	155	155	156	156	156	156	156	156	156	156	157
145	153	153	153	154	154	154	154	154	155	155	155	155	155	155	155	156	156
150	152	152	153	153	153	153	153	154	154	154	154	154	154	155	155	155	155
155	151	151	152	152	152	152	153	153	153	153	153	153	154	154	154	154	154
160	150	151	151	151	151	151	152	152	152	152	152	153	153	153	153	153	153
165	149	150	150	150	150	151	151	151	151	151	152	152	152	152	152	152	153
170	149	149	149	149	150	150	150	150	150	151	151	151	151	151	151	152	152
175	148	148	148	148	149	149	149	149	150	150	150	150	150	151	151	151	151
180	147	147	147	148	148	148	148	149	149	149	149	149	149	150	150	150	150
185	146	146	147	147	147	147	148	148	148	148	148	148	149	149	149	149	149
190	145	145	146	146	146	146	147	147	147	147	147	148	148	148	148	148	149
195	144	145	145	145	145	146	146	146	146	147	147	147	147	147	148	148	148
200	143	144	144	144	145	145	145	145	146	146	146	146	147	147	147	147	147

TABLE B FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITH A STRUCTURALLY DEFECTIVE LEAN

		TARGET WIDTH															
		1	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
DISTANCE FROM TARGET	1	53	157	169	172	174	175	176	177	177	177	178	178	178	178	178	178
	5	11	90	127	143	152	157	161	164	166	167	169	170	170	171	172	172
	10	6	53	90	113	127	136	143	148	152	155	157	159	161	163	164	165
	15	4	37	67	90	106	118	127	134	139	143	147	149	152	154	156	157
	20	3	28	53	74	90	103	113	121	127	132	136	140	143	146	148	150
	25	2	23	44	62	77	90	100	109	116	122	127	131	135	138	141	143
	30	2	19	37	53	67	80	90	99	106	113	118	123	127	130	134	136
	35	2	16	32	46	59	71	81	90	98	104	110	115	119	123	127	130
	40	1	14	28	41	53	64	74	82	90	97	103	108	113	117	121	124
	45	1	13	25	37	48	58	67	76	83	90	96	101	106	111	115	118
	50	1	11	23	33	44	53	62	70	77	84	90	95	100	105	109	113
	55	1	10	21	31	40	49	57	65	72	79	85	90	95	100	104	107
	60	1	10	19	28	37	45	53	61	67	74	80	85	90	95	99	103
	65	1	9	17	26	34	42	50	57	63	69	75	80	85	90	94	98
	70	1	8	16	24	32	39	46	53	59	65	71	76	81	86	90	94
	75	1	8	15	23	30	37	44	50	56	62	67	73	77	82	86	90
	80	1	7	14	21	28	35	41	47	53	59	64	69	74	78	82	86
	85	1	7	13	20	26	33	39	45	50	56	61	66	70	75	79	83
	90	1	6	13	19	25	31	37	43	48	53	58	63	67	72	76	80
	95	1	6	12	18	24	29	35	40	46	51	56	60	65	69	73	77
100	1	6	11	17	23	28	33	39	44	48	53	58	62	66	70	74	
105	1	5	11	16	22	27	32	37	42	46	51	55	59	64	67	71	
110	1	5	10	16	21	26	31	35	40	44	49	53	57	61	65	69	
115	0	5	10	15	20	25	29	34	38	43	47	51	55	59	63	66	
120	0	5	10	14	19	24	28	33	37	41	45	49	53	57	61	64	
125	0	5	9	14	18	23	27	31	35	40	44	47	51	55	58	62	
130	0	4	9	13	17	22	26	30	34	38	42	46	50	53	57	60	
135	0	4	8	13	17	21	25	29	33	37	41	44	48	51	55	58	
140	0	4	8	12	16	20	24	28	32	36	39	43	46	50	53	56	
145	0	4	8	12	16	20	23	27	31	34	38	42	45	48	52	55	
150	0	4	8	11	15	19	23	26	30	33	37	40	44	47	50	53	
155	0	4	7	11	15	18	22	25	29	32	36	39	42	46	49	52	
160	0	4	7	11	14	18	21	25	28	31	35	38	41	44	47	50	
165	0	3	7	10	14	17	21	24	27	31	34	37	40	43	46	49	
170	0	3	7	10	13	17	20	23	26	30	33	36	39	42	45	48	
175	0	3	7	10	13	16	19	23	26	29	32	35	38	41	44	46	
180	0	3	6	10	13	16	19	22	25	28	31	34	37	40	43	45	
185	0	3	6	9	12	15	18	21	24	27	30	33	36	39	41	44	
190	0	3	6	9	12	15	18	21	24	27	29	32	35	38	40	43	
195	0	3	6	9	12	15	17	20	23	26	29	32	34	37	39	42	
200	0	3	6	9	11	14	17	20	23	25	28	31	33	36	39	41	

DISTANCE FROM TARGET

TABLE B FOR DETERMINING ANGLE WITHIN STRIKING DISTANCE

FOR TREES WITH A STRUCTURALLY DEFECTIVE LEAN

		TARGET WIDTH															
		160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	
T E G R A T I O N A L F O R M A T I O N	1	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	
	5	173	173	174	174	174	175	175	175	175	175	176	176	176	176	176	
	10	166	167	167	168	169	169	170	170	170	171	171	172	172	172	172	
	15	159	160	161	162	163	164	164	165	166	166	167	167	168	168	169	
	20	152	154	155	156	157	158	159	160	161	162	163	163	164	164	165	
	25	145	147	149	151	152	153	154	155	156	157	158	159	160	160	161	
	30	139	141	143	145	147	148	149	151	152	153	154	155	156	157	157	
	35	133	135	137	140	141	143	145	146	147	149	150	151	152	153	154	
	40	127	130	132	134	136	138	140	142	143	145	146	147	148	149	150	
	45	121	124	127	129	132	134	136	137	139	140	142	143	144	146	147	
	50	116	119	122	124	127	129	131	133	135	136	138	139	141	142	143	
	55	111	114	117	120	122	125	127	129	131	133	134	136	137	138	140	
	60	106	110	113	115	118	121	123	125	127	129	130	132	134	135	136	
	65	102	105	108	111	114	116	119	121	123	125	127	129	130	132	133	
	70	98	101	104	107	110	113	115	117	119	122	123	125	127	128	130	
	75	94	97	100	103	106	109	111	114	116	118	120	122	124	125	127	
	80	90	93	97	100	103	105	108	110	113	115	117	119	121	122	124	
	85	87	90	93	96	99	102	105	107	109	112	114	116	117	119	121	
	90	83	87	90	93	96	99	101	104	106	108	111	113	115	116	118	
	95	80	84	87	90	93	96	98	101	103	106	108	110	112	114	115	
100	77	81	84	87	90	93	95	98	100	103	105	107	109	111	113		
105	75	78	81	84	87	90	93	95	98	100	102	104	106	108	110		
110	72	75	79	82	85	87	90	93	95	97	100	102	104	106	107		
115	70	73	76	79	82	85	87	90	92	95	97	99	101	103	105		
120	67	71	74	77	80	82	85	88	90	92	95	97	99	101	103		
125	65 <td>68</td> <td>72</td> <td>74</td> <td>77</td> <td>80</td> <td>83</td> <td>85</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td> <td>96</td> <td>98</td> <td>100</td>	68	72	74	77	80	83	85	88	90	92	94	96	98	100		
130	63 <td>66</td> <td>69</td> <td>72</td> <td>75</td> <td>78</td> <td>80</td> <td>83</td> <td>85</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td> <td>96</td> <td>98</td>	66	69	72	75	78	80	83	85	88	90	92	94	96	98		
135	61 <td>64</td> <td>67</td> <td>70</td> <td>73</td> <td>76</td> <td>78</td> <td>81</td> <td>83</td> <td>86</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td> <td>96</td>	64	67	70	73	76	78	81	83	86	88	90	92	94	96		
140	59 <td>63</td> <td>65</td> <td>68</td> <td>71</td> <td>74</td> <td>76</td> <td>79</td> <td>81</td> <td>84</td> <td>86</td> <td>88</td> <td>90</td> <td>92</td> <td>94</td>	63	65	68	71	74	76	79	81	84	86	88	90	92	94		
145	58 <td>61<td>64<td>66<td>69<td>72<td>74<td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	61 <td>64<td>66<td>69<td>72<td>74<td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td></td></td></td></td></td>	64 <td>66<td>69<td>72<td>74<td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td></td></td></td></td>	66 <td>69<td>72<td>74<td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td></td></td></td>	69 <td>72<td>74<td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td></td></td>	72 <td>74<td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td></td>	74 <td>77<td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td></td>	77 <td>79<td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td></td>	79 <td>82<td>84<td>86<td>88<td>90<td>92</td></td></td></td></td></td>	82 <td>84<td>86<td>88<td>90<td>92</td></td></td></td></td>	84 <td>86<td>88<td>90<td>92</td></td></td></td>	86 <td>88<td>90<td>92</td></td></td>	88 <td>90<td>92</td></td>	90 <td>92</td>	92		
150	56 <td>59<td>62<td>65<td>67<td>70<td>73<td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	59 <td>62<td>65<td>67<td>70<td>73<td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td></td></td></td></td></td>	62 <td>65<td>67<td>70<td>73<td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td></td></td></td></td>	65 <td>67<td>70<td>73<td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td></td></td></td>	67 <td>70<td>73<td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td></td></td>	70 <td>73<td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td></td>	73 <td>75<td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td></td>	75 <td>77<td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td></td>	77 <td>80<td>82<td>84<td>86<td>88<td>90</td></td></td></td></td></td>	80 <td>82<td>84<td>86<td>88<td>90</td></td></td></td></td>	82 <td>84<td>86<td>88<td>90</td></td></td></td>	84 <td>86<td>88<td>90</td></td></td>	86 <td>88<td>90</td></td>	88 <td>90</td>	90		
155	55 <td>57<td>60<td>63<td>66<td>68<td>71<td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	57 <td>60<td>63<td>66<td>68<td>71<td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td></td></td></td></td></td>	60 <td>63<td>66<td>68<td>71<td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td></td></td></td></td>	63 <td>66<td>68<td>71<td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td></td></td></td>	66 <td>68<td>71<td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td></td></td>	68 <td>71<td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td></td>	71 <td>73<td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td></td>	73 <td>75<td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td></td>	75 <td>78<td>80<td>82<td>84<td>86<td>88</td></td></td></td></td></td>	78 <td>80<td>82<td>84<td>86<td>88</td></td></td></td></td>	80 <td>82<td>84<td>86<td>88</td></td></td></td>	82 <td>84<td>86<td>88</td></td></td>	84 <td>86<td>88</td></td>	86 <td>88</td>	88		
160	53 <td>56<td>59<td>61<td>64<td>67<td>69<td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	56 <td>59<td>61<td>64<td>67<td>69<td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td></td></td></td></td></td>	59 <td>61<td>64<td>67<td>69<td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td></td></td></td></td>	61 <td>64<td>67<td>69<td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td></td></td></td>	64 <td>67<td>69<td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td></td></td>	67 <td>69<td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td></td>	69 <td>71<td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td></td>	71 <td>74<td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td></td>	74 <td>76<td>78<td>80<td>82<td>84<td>86</td></td></td></td></td></td>	76 <td>78<td>80<td>82<td>84<td>86</td></td></td></td></td>	78 <td>80<td>82<td>84<td>86</td></td></td></td>	80 <td>82<td>84<td>86</td></td></td>	82 <td>84<td>86</td></td>	84 <td>86</td>	86		
165	52 <td>55<td>57<td>60<td>62<td>65<td>67<td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	55 <td>57<td>60<td>62<td>65<td>67<td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td></td></td></td></td></td>	57 <td>60<td>62<td>65<td>67<td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td></td></td></td></td>	60 <td>62<td>65<td>67<td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td></td></td></td>	62 <td>65<td>67<td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td></td></td>	65 <td>67<td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td></td>	67 <td>70<td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td></td>	70 <td>72<td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td></td>	72 <td>74<td>76<td>79<td>81<td>83<td>85</td></td></td></td></td></td>	74 <td>76<td>79<td>81<td>83<td>85</td></td></td></td></td>	76 <td>79<td>81<td>83<td>85</td></td></td></td>	79 <td>81<td>83<td>85</td></td></td>	81 <td>83<td>85</td></td>	83 <td>85</td>	85		
170	50 <td>53<td>56<td>58<td>61<td>63<td>66<td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	53 <td>56<td>58<td>61<td>63<td>66<td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td></td></td></td></td></td>	56 <td>58<td>61<td>63<td>66<td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td></td></td></td></td>	58 <td>61<td>63<td>66<td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td></td></td></td>	61 <td>63<td>66<td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td></td></td>	63 <td>66<td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td></td>	66 <td>68<td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td></td>	68 <td>70<td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td></td>	70 <td>73<td>75<td>77<td>79<td>81<td>83</td></td></td></td></td></td>	73 <td>75<td>77<td>79<td>81<td>83</td></td></td></td></td>	75 <td>77<td>79<td>81<td>83</td></td></td></td>	77 <td>79<td>81<td>83</td></td></td>	79 <td>81<td>83</td></td>	81 <td>83</td>	83		
175	49 <td>52<td>54<td>57<td>59<td>62<td>64<td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	52 <td>54<td>57<td>59<td>62<td>64<td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td></td></td></td></td></td>	54 <td>57<td>59<td>62<td>64<td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td></td></td></td></td>	57 <td>59<td>62<td>64<td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td></td></td></td>	59 <td>62<td>64<td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td></td></td>	62 <td>64<td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td></td>	64 <td>67<td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td></td>	67 <td>69<td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td></td>	69 <td>71<td>73<td>75<td>77<td>79<td>81</td></td></td></td></td></td>	71 <td>73<td>75<td>77<td>79<td>81</td></td></td></td></td>	73 <td>75<td>77<td>79<td>81</td></td></td></td>	75 <td>77<td>79<td>81</td></td></td>	77 <td>79<td>81</td></td>	79 <td>81</td>	81		
180	48 <td>51<td>53<td>56<td>58<td>61<td>63<td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	51 <td>53<td>56<td>58<td>61<td>63<td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td></td></td></td></td></td>	53 <td>56<td>58<td>61<td>63<td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td></td></td></td></td>	56 <td>58<td>61<td>63<td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td></td></td></td>	58 <td>61<td>63<td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td></td></td>	61 <td>63<td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td></td>	63 <td>65<td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td></td>	65 <td>67<td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td></td>	67 <td>70<td>72<td>74<td>76<td>78<td>80</td></td></td></td></td></td>	70 <td>72<td>74<td>76<td>78<td>80</td></td></td></td></td>	72 <td>74<td>76<td>78<td>80</td></td></td></td>	74 <td>76<td>78<td>80</td></td></td>	76 <td>78<td>80</td></td>	78 <td>80</td>	80		
185	47 <td>49<td>52<td>54<td>57<td>59<td>61<td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	49 <td>52<td>54<td>57<td>59<td>61<td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td></td></td></td></td></td>	52 <td>54<td>57<td>59<td>61<td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td></td></td></td></td>	54 <td>57<td>59<td>61<td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td></td></td></td>	57 <td>59<td>61<td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td></td></td>	59 <td>61<td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td></td>	61 <td>64<td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td></td>	64 <td>66<td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td></td>	66 <td>68<td>70<td>72<td>74<td>76<td>78</td></td></td></td></td></td>	68 <td>70<td>72<td>74<td>76<td>78</td></td></td></td></td>	70 <td>72<td>74<td>76<td>78</td></td></td></td>	72 <td>74<td>76<td>78</td></td></td>	74 <td>76<td>78</td></td>	76 <td>78</td>	78		
190	46 <td>48<td>51<td>53<td>56<td>58<td>60<td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	48 <td>51<td>53<td>56<td>58<td>60<td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td></td></td></td></td></td>	51 <td>53<td>56<td>58<td>60<td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td></td></td></td></td>	53 <td>56<td>58<td>60<td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td></td></td></td>	56 <td>58<td>60<td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td></td></td>	58 <td>60<td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td></td>	60 <td>62<td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td></td>	62 <td>65<td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td></td>	65 <td>67<td>69<td>71<td>73<td>75<td>77</td></td></td></td></td></td>	67 <td>69<td>71<td>73<td>75<td>77</td></td></td></td></td>	69 <td>71<td>73<td>75<td>77</td></td></td></td>	71 <td>73<td>75<td>77</td></td></td>	73 <td>75<td>77</td></td>	75 <td>77</td>	77		
195	45 <td>47<td>50<td>52<td>54<td>57<td>59<td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	47 <td>50<td>52<td>54<td>57<td>59<td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td></td></td></td></td></td>	50 <td>52<td>54<td>57<td>59<td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td></td></td></td></td>	52 <td>54<td>57<td>59<td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td></td></td></td>	54 <td>57<td>59<td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td></td></td>	57 <td>59<td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td></td>	59 <td>61<td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td></td>	61 <td>63<td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td></td>	63 <td>65<td>67<td>69<td>71<td>73<td>75</td></td></td></td></td></td>	65 <td>67<td>69<td>71<td>73<td>75</td></td></td></td></td>	67 <td>69<td>71<td>73<td>75</td></td></td></td>	69 <td>71<td>73<td>75</td></td></td>	71 <td>73<td>75</td></td>	73 <td>75</td>	75		
200	44 <td>46<td>48<td>51<td>53<td>55<td>58<td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td></td></td></td></td></td></td>	46 <td>48<td>51<td>53<td>55<td>58<td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td></td></td></td></td></td>	48 <td>51<td>53<td>55<td>58<td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td></td></td></td></td>	51 <td>53<td>55<td>58<td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td></td></td></td>	53 <td>55<td>58<td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td></td></td>	55 <td>58<td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td></td>	58 <td>60<td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td></td>	60 <td>62<td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td></td>	62 <td>64<td>66<td>68<td>70<td>72<td>74</td></td></td></td></td></td>	64 <td>66<td>68<td>70<td>72<td>74</td></td></td></td></td>	66 <td>68<td>70<td>72<td>74</td></td></td></td>	68 <td>70<td>72<td>74</td></td></td>	70 <td>72<td>74</td></td>	72 <td>74</td>	74		

DISTANCE
FROM
TARGET

APPENDIX E: HAZARD TREE RECORD FORMS

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

CASE INCIDENT RECORD

1. ORGANIZATION CODE <div style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></div>		2. ORGANIZATION (PARK) NAME			3. LOCATION CODE		4. CASE/INCIDENT NO.			
5. LOCATION OF INCIDENT		6. WHEN DID IT OCCUR?		MO.	DAY	YR.	24 HOUR TIME	HRS.	MIN.	7. DAY OF WEEK
8. OFFENSE/INCIDENT CODE		9. NATURE OF INCIDENT					10. HOW REPORTED			
11. REPORTED BY				12. ADDRESS				13. PHONE HOME BUSINESS		
14. RECEIVED BY				15. WHEN RECEIVED: DATE		16. TIME BROADCAST		17. WHEN INVESTIGATED DATE TIME		
18. INVESTIGATED BY				19. OFFICER/RANGER NO.		20. WHEN CLEARED DATE TIME		21. DISPOSITION		

22. INVOLVED PERSONS	23. ADDRESS	24. PHONE	25. SEX	26. RACE	27. AGE	28. DATE OF BIRTH
1						
2						
3						
4						

29. DETAILS OF INCIDENT

30. QUANTITY	31. PROPERTY STOLEN OR DAMAGED	32. ESTIMATED VALUE	33. RECOVERED	
			DATE	VALUE
35. PROPERTY CODE OF HIGHEST VALUE	36. TOTAL		37. TOTAL	

INVESTIGATED BY (Signature and Date) APPROVED BY (Signature and Date)



FORM NO. 10-344
(Rev. 3-73)U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
SUPPLEMENTARY CASE/INCIDENT RECORD

ORGANIZATION (PARK) NAME	CASE/INCIDENT NUMBER <table border="1"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>							
LOCATION OF INCIDENT	DATE OF INCIDENT MO DA YR <table border="1"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>							
NATURE OF INCIDENT								
COMPLAINANT'S NAME	COMPLAINANT'S ADDRESS							

RESULTS OF INVESTIGATION

SUBMITTED BY (SIGNATURE AND DATE)

APPROVED BY (SIGNATURE AND DATE)



(Mechanical break, collapse, or uprooting)

REPORTING AGENCY: _____ UNIT: _____

(A) Tree and stand

Species: _____
 Approximate dbh of tree: _____ inches
 Approximate age of tree: _____ years
 Forest type: _____
 Stand age class: ☐ Overmature
 ☐ Mature
 ☐ Young-growth
 ☐ All-age

Elevation of site: _____

(B) Class of mechanical failure

- ☐ Upper bole (top half)
- ☐ Lower bole
- ☐ Butt (lower 6 feet)
- ☐ Limb
- ☐ Root, including uprooting

(C) Tree defect or fault leading to failure ②

- ☐ Rot (trunk, limb, or root)
- ☐ Sweep
- ☐ Tree dead - snag
- ☐ Fire wound
- ☐ Leaning
- ☐ Lightning wound
- ☐ Mechanical wound
- ☐ Cracks or splits
- ☐ Fork or multiple top
- ☐ Twin bole or basal fork
- ☐ Dead top or branch
- ☐ Widow-maker or hang-up
- ☐ Canker, rust
- ☐ Canker, mistletoe
- ☐ Other: _____
- ☐ Unknown or none

(D) Contributing factors

- | | |
|--|--|
| <input type="checkbox"/> Wind | <input type="checkbox"/> Stream bank erosion |
| <input type="checkbox"/> Snow | <input type="checkbox"/> Shallow rooting |
| <input type="checkbox"/> Erosion | <input type="checkbox"/> Tree striking tree |
| <input type="checkbox"/> Soil - saturation | <input type="checkbox"/> Other: _____ |
| | <input type="checkbox"/> Unknown or none |

(E) Time and location of incident

Approximate hour: _____
 Month, year: _____
 County: _____
 State: _____
 Site open for public use: Yes No

(F) Land ownership

- ☐ Federal
☐ State
☐ Other public: _____
☐ Private
☐ Public utility

(G) Site category

- ☐ Established camp or picnic ground
☐ Other established public use site ⁽³⁾
☐ Volunteer site ⁽⁴⁾
☐ Marked trail
☐ Special use site ⁽⁵⁾
☐ Roadside
☐ Residence site ⁽⁶⁾
☐ Other: ⁽⁷⁾ _____
☐ Urban _____

(H) Property or person directly affected

- _____ Agency
 _____ Recreationist
 _____ Forest industry
 _____ Permittee-Concessionaire
 _____ Other: _____
 _____ Contractor
 _____ Public utility

(I) Consequences

- ☐ Clean-up work required
☐ Property damaged: _____
☐ Property loss estimate: \$ _____
☐ Injuries (Do not give tree values)
☐ Medical attention required
☐ Fatalities

(J) Name of site: ⑧

Comments: _____

Only failures of a size capable of inflicting some damage or injury should be reported. Minor limb failures should not be reported unless they were potentially dangerous. Do not report simple death of a tree or part of a tree unless it resulted in mechanical failure. Trees removed prior to failure should not be reported.

APPENDIX F: COMMON HAZARDS OF PARK TREE SPECIES

Alder (*Alder incana*, *A. sinuata*)

Principal hazards: Root loosening by water (Wagener, 1963).

Quaking Aspen (*Populus tremuloides*)

Principal hazards: Killed trees or tops (Wagener, 1963). Sporophores usually indicate decay that extends 5-6 feet above and below the conk. Aspen, because of their fragile bark, are especially susceptible to trunk injuries. Trees in developed recreation sites are often injured by visitors; such injuries often lead to infection by canker producing fungi. Cankers do not weaken trees structurally unless they are large or are infected by decay fungi. Increment cores may be necessary to define the amount of defect. However, cores should be taken only when necessary, as they produce wounds which may provide infection sites for canker and decay fungi. Also, cores taken from trees with internal decay provide new points from which existing decay can move into unaffected tissues formed since the decay process was initiated in the tree. (Johnson, 1981)

Black Cottonwood (*Populus trichocarpa*)

Principal hazards: Cankers, heart and sap rots, undermined roots.

The wood of cottonwoods is soft and quite brash, as well as having little resistance to decay. Cottonwoods are also subject to several bark canker diseases that may be followed by decay. On this account they should be inspected at least annually for defects that could lead to breakage. Prompt action should be taken to remedy any potentially hazardous conditions found. Near streams the undermining of root systems during high water should be watched. (Wagener, 1963) The main defect of cottonwood is large dead or rotten branches. Large trees are sometimes rotten and the amount of sound wood should be measured on increment cores. Slime flux (foul-smelling and unsightly bleeding from wounds) and wetwood should not be confused with woodrotting fungi. These indicators are common in hardwoods and usually do not indicate decay. Many river bottom trees are not windfirm because of the high water table and coarse soil structure. (Johnson, 1981)

Rocky Mountain Maple (*Acer glabrum*)

Birch (*Betula glandulosa*, *B. occidentalis*, *B. papyrifera*)

Pines (*Pinus* sp.)

Principal hazards: High horizontal cankers, heart rot from fire wounds, large low-crotched forks. Damage to life and property from pines, ..., has occurred almost exclusively during severe storms. These storms have

been intense enough to cause the breakage of much sound wood or the uprooting of trees with relatively sound root systems. The sapwood of most California pines is quite thick in proportion to the total cross section, and the heartwood tends to be relatively sound except from occasional old, overmature specimens. In these trees the rot is usually in association with old fire wounds. On the other hand the wood is mechanically not as strong as in some other conifers, such as Douglas-fir. Consequently the wood of pines may break under the stress of exceptionally high winds, whereas species with tougher wood can be expected to remain intact when under the same stresses.

Any trunk abnormality that tends to seriously disrupt the normal round form at some particular point is likely to increase the possibility of breakage there. Thus, in at least one district in California, deep, horizontal cankers at some distance from the ground have resulted in an occasional breaking over of the cankered trunks at the canker during severe storms. On the other hand breakage has not been noted from cankers of the same type located within a few feet of the ground. The wood around these cankers (which are probably caused by a tree rust) is hard and tough. Only when the canker depressions become deep and occur 16 or more feet from the ground do they seem to weaken the trunk of the affected tree enough to cause breakage in occasional cases during severe windstorms.

In a few cases large forks in pines have broken out during heavy winds.... However, this does not mean that all forked pines should be considered hazardous. (Wagener, 1963) Dwarf mistletoe is the major disease of pines in the Rocky Mountains. Large witches'-brooms should be removed to eliminate this hazard and improve tree vigor. Wood-rotting fungi are common in pines. Indicators of rot include basal fire scars, unusual swellings, swollen or punky knots, and sporophores. However, because of the dry climate in this Region, most wood-rotting fungi rarely form easily visible sporophores. Burls and cankers commonly occur on pines, but do not constitute a hazard unless they are so extensive as to weaken stem structure or are complicated by rot. Increment cores should be taken to determine the amount of sound wood in trees exhibiting signs of decay. (Johnson, 1981)

Lodgepole Pine (*Pinus contorta*)

Lodgepole pine has thin bark which is easily damaged resulting in increased susceptibility to decay (Johnson, 1981).

Ponderosa Pine (*Pinus ponderosa*)

Western White Pine (*Pinus monticola*)

Limber Pine (*Pinus flexilis*)

Whitebark Pine (*Pinus albicaulis*)

Larch (*Larix occidentalis*, *L. lyalli*)

Fir (*Abies lasiocarpa*, *A. grandis*)

Rot commonly occurs in overmature spruce and true fir. Subalpine fir is particularly susceptible to decay fungi and the frequency and extent of rot increases markedly with age. Trunk wounds, punky knots, frost cracks, and broken tops often indicate decay in spruce and fir; whereas, burls and cankers do not. Sporophores, when present, indicate advanced decay. When a defect is suspected, increment cores should be taken to confirm the presence of rot. Spruce and fir usually are not windfirm because of shallow root systems. Therefore any damage to the roots will increase the probability of windthrow. Rust brooms, unless large, are not a serious hazard. Both spruce and true fir are relatively tolerant of trunk damage, but once damage occurs they are very susceptible to decay. (Johnson, 1981)

Engelmann Spruce (*Picea engelmanni*)

See Johnson's (1981) remarks for fir above.

Douglas Fir (*Pseudotsuga menziesii*)

Western Hemlock (*Tsuga heterophylla*)

APPENDIX G

LITERATURE CITED

Hagle, Susan K., Scott Tunnock, Kenneth E. Gibson, Carma J. Gilligan. 1987. Field guide to diseases and insect pests of Idaho and Montana forests. USDA For. Ser. Nor. Reg., Missoula, Montana.

Hamilton, Jr. David A. and Bruce M. Edwards. 1976. Modeling the probability of individual tree mortality. USDA For. Ser. Res. Paper INT-185.

Johnson, David W. 1981. Tree hazards; recognition and reduction in recreation sites. USDA For Ser. Tech. Rep. R2-1.

Larson, Rolf L. 1984. Report on hazard tree identification in Glacier National Park, Montana. Unpublished Report. Glacier National Park.

McArthur, Katherine L. 1977. Survey of fallen trees in headquarters area. Unpublished Report. Glacier National Park.

USDI. 1991. Natural Resources Management Guideline. NPS-77.

Wallis, G.W., D.J. Morrison, and D.W. Ross. 1980. Tree hazards in recreation sites in British Columbia. British Columbia Ministry of Lands, Parks and Housing and Canadian Forestry Service Joint Report No. 13.

Wagener, Willis. 1963. Judging hazard from native trees in California recreational areas: a guide for professional foresters. USDA For. Ser. Res. Paper PSW-P1.

ADDITIONAL READING

Schmierer, Alan. 1992. DRAFT Western Region directive on the management of vegetation hazards. National Park Service, Western Region, San Francisco, California.

USDA, Forest Service and Idaho Department of State Lands. Forest insect and disease identification and management. USDA, Forest Service, Northern Region. Missoula, Montana.



